

Lack of reproducibility. JOHN CHRISTY

Assumption that warming is dangerous. The NCA5 neglects benefits from more CO₂ in the atmosphere and from warming.

Implausible extreme emissions scenarios. It is now well known that the extreme emissions scenarios are implausible – UN climate negotiators (COP) have dropped the extreme emissions scenarios from their analyses and projections since 2021. Nevertheless, a word search of the NCA5 shows that a majority of the mentions were of the extreme emissions scenario

Uncritical acceptance of climate model outputs. The NCA5 uncritically accepts climate model outputs for regional climate impact assessments and 21st century projections. This uncritical acceptance is not justified in the Report, and is at odds with IPCC AR6 WG1 Report (Chapter 10)

Overconfidence of conclusions. The terminology NCA5 uses for confidence levels is inflated, leading to overconfidence in the conclusions. ~~NCA5 conclusions with medium confidence are justified by “Suggestive evidence (a few sources, limited consistency, models incomplete, methods emerging, etc.) competing schools of thought. NCA conclusions with high confidence are justified by “Moderate evidence (several sources, some consistency, methods vary and/or documentation limited, etc.), medium consensus (DESCRIBED AT LENGTH ELSEWHERE~~

Failure to adequately assess uncertainties. The NCA5 briefly mentions uncertainties for each major conclusion in a Traceability Account at the end of each chapter. These uncertainties are ~~not included in the main text and~~ do not appear to influence the conclusions or the confidence levels. The main text neglects obvious representations of uncertainty such as the statistical significance of trends

Emphasis on a single solution. The document advocates extensively for ~~for a single solution—~~ replacement of fossil fuels with wind and solar power CHECK

The magnitude of the bias and lack of objectivity in the NCA5 Report is evidenced by comparing it with our DOE document. This document was authored by five scientists whose research and perspectives challenge the prevailing narrative – a category of author that was not included by the NCA5. The DOE included topics and data that were not included in the NCA5, and drew substantially different conclusions from the NCA5, particularly in context of a more comprehensive uncertainty analysis. ETC

Introduction

This report responds to a request from OSTP Director Michael Kratsios (reproduced in Appendix XX) that we assess the suitability of the Fifth National Climate Assessment for informing climate and energy policies.

~~To carry out our work~~ To conduct this assessment, we reviewed NCA5 itself, NASEM review of the Third Order Draft and the USGCRP responses to the review, We have also drawn upon our experience in reading, writing, and leading advisory reports.

We find that NCA5 should not be relied on for policy making as it is an incomplete and misleadingly picture of our understanding of the changing climate and the risks it poses to the nation. NCA5 is most obviously incomplete because there have been significant developments in climate science since its literature cutoff date of 2022. We have reviewed those developments in a separate report to Energy Secretary Wright. NO PARA BREAK

~~As importantly~~ Further, NCA5 misleads in its portrayal of climate science by omitting key elements of data or understanding even as of 2023. ~~In short, it is completely factual, but factually incomplete.~~ I DON'T LIKE THIS STATEMENT HERE. IT IMPLIES THAT THE NCA5 IS COMPLETELY FACTUAL. The overall effect of those omissions is an excessively dire picture of climate risk.

Our report begins with background on the National Climate Assessments. We then discuss the standards by which we have assessed NCA5, followed by specific deficiencies that we have we've identified. ~~The final section offers some recommendations on the substance and process for the next National Climate Assessment, NCA6, due ???~~

About the National Climate Assessments

The U.S. Global Change Research Program (USGCRP) was established by Presidential Initiative in 1989 and mandated by Congress in the Global Change Research Act (GCRA) of 1990 to develop and coordinate “a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.”

The National Climate Assessment (NCA) Reports evolved from the GCRA requirement to

Prepare and submit to the President and the Congress an assessment which (1) integrates, evaluates, and interprets the findings of the Program and discusses the scientific uncertainties associated with such findings; (2) analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity; and (3) analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years.

The five NCA Reports to date have interpreted this mandate in different ways:

- NCA1 (2000) was a multidisciplinary effort to study and portray in regional detail the potential effects of human-induced global warming on the United States.
- NCA2 (2009) was a relatively short report that not only focused on the potential consequences of climate change, but also sought to identify potential adaptation measures and identify the highest priorities for future research.

- NCA3 (2014) was an expanded effort that continued along the lines of NCA2, and was distinguished by a comprehensive review process, including a review by the National Academy of Sciences.
- NCA4 (2017/2018) was an expanded effort published in two volumes: I Climate Science Special Report, and II Impacts, Risk, and Adaptation in the United States. This was the first NCA report to devote significant effort to assessing climate science. NCA4 introduced a traceability analysis for each key finding, including a cursory description of uncertainties.
- NCA5 (2023) returned to a single volume format, reducing discussion of climate science to a cursory two chapters, with continuing with a focus on regional and sectoral impacts of climate change. NCA5 expanded its remit to topics that are arguably outside the purview of the USGCRP, focusing on “Climate Action” and policy recommendations with a social justice emphasis. NCA5’s self-description is reproduced as Appendix II.

These successive interpretations of the NCA are poorly aligned with the GCRA’s statutory requirements. Only NCA4 gives serious consideration to climate science, which receives the great majority of USGCRP funding, and even then misrepresents some important points (see the Box nearby for an example). Natural climate variability is essentially dismissed as unimportant in NCA4 and barely mentioned in NCA5 in most contexts, despite the mandate to include both human-caused and natural climate change. Most significantly, NCA5 has redirected the focus away from climate science and even the hazard elements of impacts, towards evaluation of societal vulnerabilities and advocacy for particular policy options, especially wind and solar power. The cover image for the NCA5 Report is the installation of a solar panel.

START BOX

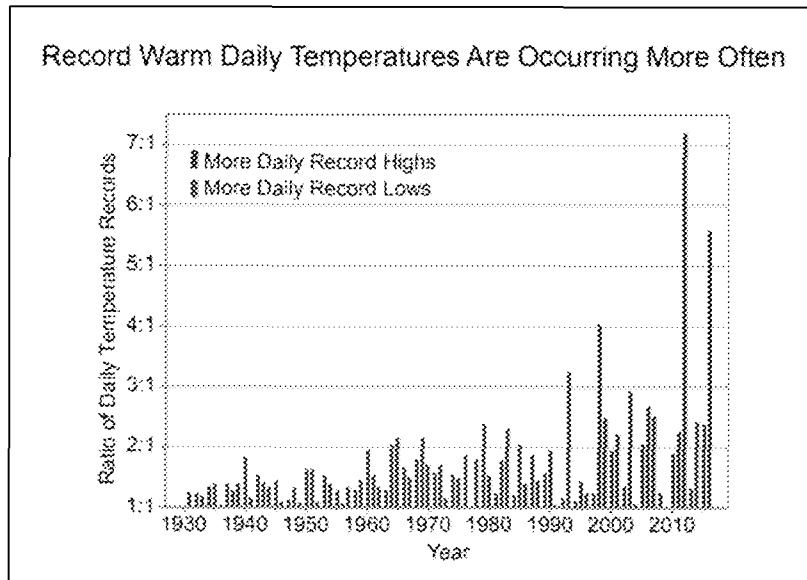
NCA4’s Figure ES.5: A Tale of Deception and Review Failure

A disappointing example of NCA4’s misrepresentation of climate science involves U.S. temperature extremes. Here is a summary of the issue; details can be found in Koonin (2024).

NCA4’s Part I (Climate Science Special Report, CCSR) says (prominently and with *Very High Confidence*) on Page 19 of the Executive Summary:

There have been marked changes in temperature extremes across the contiguous United States. The number of high temperature records set in the past two decades far exceeds the number of low temperature records.

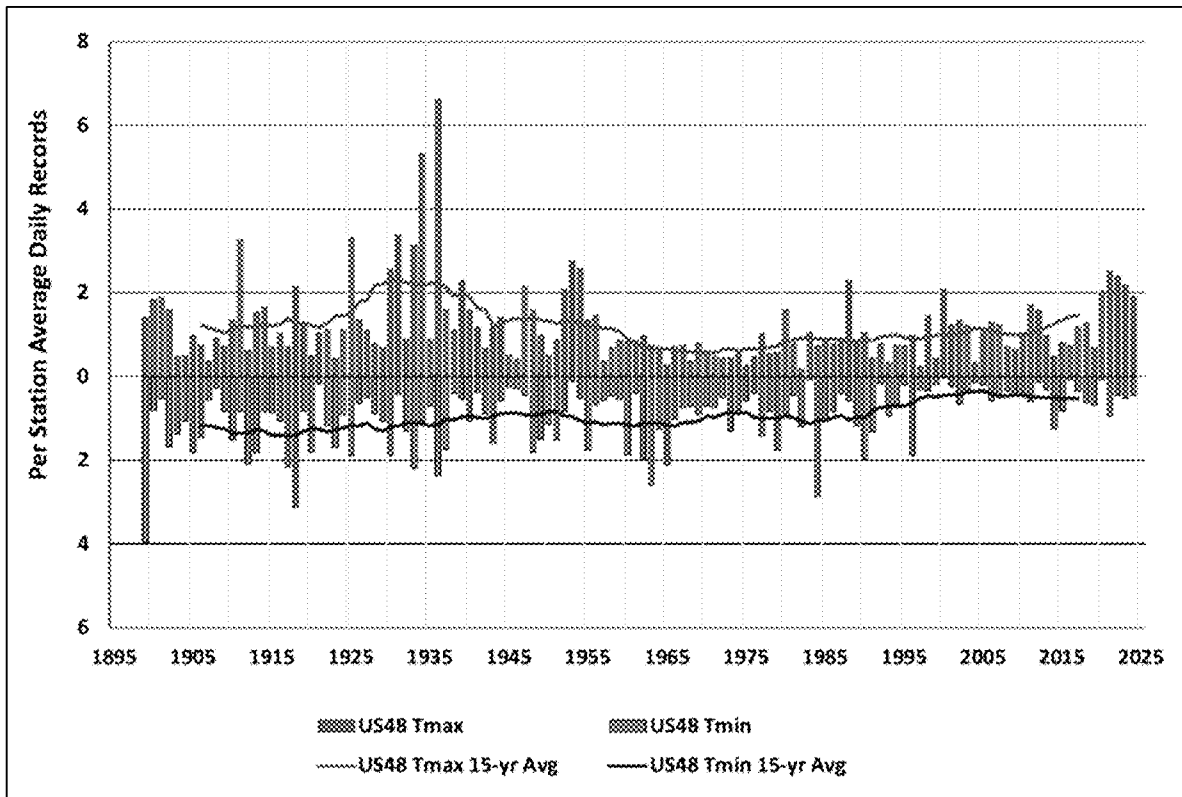
and offers this figure in support:



CSSR Figure ES.5 The ratio of the number of daily record high temperatures to daily record low temperatures for many stations across the 48 contiguous states is shown for each year from 1930 to 2017. The lighter bars show a year in which there were more record highs than lows, while the darker bars show years in which there were more record lows than highs. The height of the bar indicates the ratio of record highs to record lows for each year. For example, a ratio of 2:1 for a dark bar means that the stations had twice as many record daily lows as record daily highs for that year. (CSSR, 2017)

Three idiosyncratic choices combine to generate the figure's seemingly alarming rise in recent decades. First, because the record extremes tallied are defined conventionally (i.e., each more extreme than any preceding value in the history), the numbers of record highs and record lows are both expected to decline through the years (it becomes increasingly unlikely that a record will be exceeded). Second, the graph displays not the numbers of record highs and lows, but rather their ratio. And finally, the history begins only in 1930 when, in fact, data exist beginning in the late 19th Century. The upshot of these choices is that the resultant figure is guaranteed to show a long period of quiescence around followed by dramatic variations, creating the impression of large changes in recent decades; ~~even if they aren't present.~~

Figure 6.3.3 of our report (reproduced below) shows the results of a proper analysis – defining each record as the singular extreme in the history, displaying numbers of warm and cold records separately, and beginning the analysis in 1899 rather than 1930. It makes evident the exceptional heat of the 1920s and especially the 1930s, peaking in 1936. The increased heat of the past five years is too brief to be deemed climatically significant and, in any event, occurred after the CSSR was published in 2017. On the cold side, the Valentine's Day Arctic outbreak in Feb 1899 stands as the most extensive cold extreme experienced by CONUS, with 1917 in 2nd place. The frequency of cold records has declined, especially over the last quarter of the period in which only 13 percent of the extreme cold events were measured. In contrast, 25 percent of the extreme Tmax records were achieved in the last quarter, in accordance with statistical expectations. As a result, the ratio shown in the CSSR explodes in recent decades. And the overall reduction in numbers of both cold and hot extremes over the past century indicates a climate *less* prone to extremes, in sharp contrast to the title of the CSSR figure, "Record Warm Daily Temperatures Are Occurring More Often".



Number of daily record High (red) and Low (blue) temperatures for warm and cold seasons in the CONUS. The lines represent the 15-year running, centered average. Source: 1,211 USHCN stations supplemented as needed to achieve a minimum of 92 percent of observations in the 126-year period since Dec 1898. US48: contiguous U.S. states. Tmax: maximum temperature. Tmin: minimum temperature.

The National Academies' expert review panel criticized the discussion of temperature extremes in a late draft of the CSSR. In reference to the CSSR's Key Finding 2 of Chapter 6, they said:

Further, it is difficult to understand how a statement that includes increases in extreme warmth can be associated with a high confidence or extremely likely statement, given that most of the graphics in this chapter show a decrease in extreme warmth in the historical record.

The Federal official in charge of the CSSR (Michael Kuperberg, Executive Director of the USGCRP) responded to the Academies' review by noting that

Almost every recommendation from the NAS was incorporated [in the final version]... and a new figure was added on changes in record high and low temperatures

The "new figure" referred to is the Figure ES.5, which did not appear in the draft reviewed by the Academies' panel. It seems unlikely that the Academies panel ever saw that figure because they surely would have commented if they had and it wouldn't have survived to publication. And the figure's problems were evidently not flagged (or were ignored) in the subsequent internal government reviews.

While the following statement has far less headline potential than that from the CSSR’s page 19 quoted at the beginning of this box, it has advantage of being correct:

There have been some changes in temperature extremes across the contiguous United States. The annual number of high temperature records set shows no significant trend over the past century nor over the past 40 years, but the annual number of record cold nights has declined by a factor of 4 since 1895, somewhat more rapidly in the past 30 years.

END BOX

Standards for Assessing NCA5

Good climate and energy policies will balance the risks and benefits of a changing climate against the world’s growing demand for reliable and affordable energy. To strike that balance, policymakers must understand at least two complex and nuanced topics –the certainties and uncertainties of climate science and the technoeconomic realities of energy systems. Experts in those subjects are the only people who can bring the facts to the discussion and so have a unique responsibility to communicate their understanding to non-experts clearly, completely, and without bias.

Expertise in energy systems resides largely in the private sector, where it is essential to providing the reliable and affordable energy services that are the lifeblood of society. Understanding is therefore continually refined and tested by the discipline of the marketplace. In contrast, climate science expertise is found largely in the non-profit realm of universities and government laboratories and so has a more academic character.

Because climate is at the core of human existence, it can engender passion and emotion. Indeed, some younger climate scientists have gone into the field to “save the planet.” So it isn’t surprising that objectivity can suffer when climate scientists communicate their understanding to non-experts. Further, the field of climate science has been politicized by NetZero mandates. ~~When that happens, it~~ This lack of objectivity usurps the public’s right to make informed choices and undermines their confidence in the scientific enterprise.

Philip Handler, President of the National Academy of Sciences, identified the problem in a 1980 editorial that resonates eerily four decades later:

Difficulty arises in the scientific community from confusion of the role of scientist *qua* scientist with that of scientist as citizen, confusion of the ethical code of the scientist with the obligation of the citizen, blurring the distinction between intrinsically scientific and intrinsically political questions. When scientists fail to recognize these boundaries, their own ideological beliefs, usually unspoken, easily becloud seemingly scientific debate.

Good scientific input to policymaking starts with good science. President Trump’s executive order of May 23, 2025, “Restoring Gold Standard Science” enumerates some of the characteristics of good science:

- i. reproducible;
- ii. transparent;

- iii. communicative of error and uncertainty;
- iv. collaborative and interdisciplinary;
- v. skeptical of its findings and assumptions;
- vi. structured for falsifiability of hypotheses;
- vii. subject to unbiased peer review;
- viii. accepting of negative results as positive outcomes; and
- ix. without conflicts of interest.

Although these should be self-evident to those trained in science, it is surprising that some have found them controversial.

But advice on climate risk has other desiderata, including statements about the strength of climate knowledge. The IPCC's approach is based on judgment of the available evidence and agreement among experts. More sophisticated knowledge characterizations for risk management include: REFERENCE
AVEN

- The degree to which the assumptions made are reasonable/realistic based on background knowledge—concern about the focus on implausible emissions scenarios RCP8.5/SSP5–8.5
- The degree to which data/information exists and are reliable and relevant—the historical and paleo database is inadequate for a complete characterization of natural climate variability on multi-decadal to millennial time scales
- The degree to which there is disagreement among experts (including those from different environments or academic fields)—attempts to suppress disagreement and alternative perspectives among experts
- The degree to which the phenomena involved are understood and accurate models exist—concerns about the fidelity and utility of climate models
- The degree to which the knowledge has been thoroughly examined with respect to unknown knowns and—neglect of the unknown knowns associated with natural climate variability

Deficiencies in NCA5

We summarize here some salient deficiencies we've identified in NCA5. Some of them are endemic, while others are specific to key points that NCA5 makes; ~~some deficiencies have developed as the result of new data or analyses since NCA5's preparation in 2023.~~

In identifying these deficiencies, we have examined NCA5 itself, the NASEM review of it's the Third Order Draft and USGCRP response to that review, as well as prior NCA Reports. We have also drawn upon our decades of experience in the science and writing advisory reports, as well as the recent assessment of climate science we prepared for the DOE.

We have limited our scope to focused on NCA5's Chapters 1-3 and selected additional sections. ~~In part because this is the core of our expertise. Further, t~~These chapters cover the foundational climate science, so that the validity of the later chapters rest on them. ~~And if these chapters have so many problems, it's that the subsequent ones will as well.~~

[few-line descriptions of the individual problems go here. We'll have to see how to parse or group and order them.]

- Misrepresentation of changes in extreme precipitation
- Misrepresentation of heat extremes
- Misrepresentation of snowfall [
- Pervasive advocacy language and promotional tone
- Overstating what underlying sources show
- Uncritical definition of scientific “advances”
- Sweeping generalizations regarding complex matters
- Hurricanes
- Projections of Sea Level Rise
- RCP8.5
- Ambiguous use of “climate change”
- Misrepresentation of historical data
- Misrepresentation of the potential of wind and solar
- ...

Summary Assessment of NCA5

As such, the NCA Reports, and particularly the NCA5, are in many ways non-compliant with the GCRA mandate:

- Failure to adequately assess climate science (with the exception of NCA4)
- Failure to adequately consider natural climate variability in attribution analyses and projections
- Failure to adequately assess uncertainties.

Further, the confidence levels in the NCA reports are vastly inflated, based on terminology alone. NCA5 conclusions with medium confidence are justified by “Suggestive evidence (a few sources, limited consistency, models incomplete, methods emerging, etc.) competing schools of thought. NCA conclusions with high confidence are justified by “Moderate evidence (several sources, some consistency, methods vary and/or documentation limited, etc.), medium consensus.

~~we’ve not identified all, and there is certainly much that’s correct and up to standards, but sufficient problems to discount the whole~~

In summary, the NCA reports have arguably been off the mark since the inception of the program. There are many topics that the NCA should have considered but didn’t, and the NCA5 in particular has considered topics outside the remit of the USGCRP. The neglect of critical topics and credible uncertainty analyses has led to bias in the reports.

As such, the NCA reports are not an objective source of information to inform U.S. policy.

From: Ross McKittrick <ross.mckitrick@gmail.com>
Sent: Friday, August 8, 2025 3:29 PM
To: Steven Koonin
Cc: Roy Spencer; John Christy; Judith Curry
Subject: Re: From the President: Endangerment Finding

Ironic given the number of people who accused us of misrepresenting "the science" but she misrepresents what we said. From our executive summary:

Both models and experience suggest that CO2-induced warming might be less damaging economically than commonly believed, and excessively aggressive mitigation policies could prove more detrimental than beneficial [Chapters 9, 10, Section 11.1]. Social Cost of Carbon estimates, which attempt to quantify the economic damage of CO2 emissions, are highly sensitive to their underlying assumptions and so provide limited independent information [Section 11.2].

From the Ch 11 summary

Mainstream climate economics has recognized that CO2-induced warming might have some negative economic effects, but they are too small to justify aggressive abatement policy and that trying to “stop” or cap global warming even at levels well above the Paris target would be worse than doing nothing. An influential study in 2012 suggested that global warming would harm growth in poor countries, but the finding has subsequently been found not to be robust. Studies that take full account of modeling uncertainties either find no evidence of a negative effect on global growth from CO2 emissions or find poor countries as likely to benefit as rich countries.

The criticism is of aggressive or excessively aggressive abatement policy. We also point out that if certain assumptions hold, then aggressive policy can be justified.

On Fri, Aug 8, 2025 at 2:42 PM Steven Koonin <steven.koonin@gmail.com> wrote:
See the first section in the email below from NAS President McNutt.

She mischaracterizes the CWG report. I don't think we anywhere argued “that the economic costs of regulation outweigh the potential benefits.” Or am I mis-remembering :)

Do you think she even read the report?

SEK

Begin forwarded message:

From: NAS Members' Update <info@nationalacademies.org>
Date: August 8, 2025 at 14:32:12 EDT
To: Steven Koonin <koonin@stanford.edu>
Subject: From the President: Endangerment Finding
Reply-To: us8-6d9d5d2823-c30e00b9e2@inbound.mailchimpapp.net

[View this email in your browser](#)



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From the President: Endangerment Finding

Many members have expressed concern about the **Environmental Protection Agency's proposal to rescind the endangerment finding** that has provided the scientific basis for EPA's regulations of greenhouse gases over the last 15 years. The EPA's rationale relies heavily on a **recent report by 5 researchers** who question the prevailing scientific consensus on climate change and argue that the economic costs of regulation outweigh the potential benefits.

The deadline for public comment on this proposal is September 15. For this reason, the NRC is conducting a fast-track study to review the latest scientific evidence on whether greenhouse gas emissions endanger public health and welfare in the U.S. With partial funding from the Cicerone fund—to which so many members regularly contribute—we will launch this study immediately. Our goal is to assemble a balanced committee from academia, industry, and other sectors who are knowledgeable on the issues, open-minded to both the strengths and weaknesses of climate science, and who have avoided taking strong advocacy positions.

While the NRC has a large body of consensus reports on the topic of climate change, many are more than a decade old, and more recent reports do not specifically address aspects of scientific understanding and evidence that are directly relevant to the EPA's recent proposal. These earlier studies will provide input to this rapid response report but are an insufficient basis for a statement by the Academy presidents about the proposed EPA action.

I hope that NAS members, if asked to contribute to this effort, will do everything in their power to serve.

Protecting the Data of U.S. Statistical Agencies

In a statement, the presidents of the National Academy of Sciences and National Academy of Medicine urge federal leaders to respect and safeguard the integrity and objectivity of federal statistical agencies and the information they produce, which is vital to public policy and essential to the nation's economic well-being.

NAS Selects Monica Feit as Executive Officer



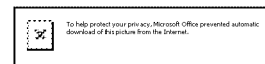
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The National Academy of Sciences has named **Monica Feit** as its next executive officer, effective October 4, 2025. In this role, Feit will oversee NAS core membership activities, including the election of its officers and members and their annual and regional meetings, as well as the offices of the NAS president, vice president, home secretary, and governing Council. Currently the executive director of the National Academies' health and medicine division, Feit has held various positions with the institution for more than 15 years. Feit will succeed NAS executive officer **Ken Fulton**, who will serve as senior advisor to the NAS President, full time until his retirement in January 2026 and then part time as needed, following more than five decades of service to the NAS. **Read the press release.**

2026 Mirzayan Fellowship: Call for Applications and Sponsorship Opportunity



Applications are now open for the **2026 Christine Mirzayan Science & Technology Policy Graduate Fellowship Program**. Eligible applicants include current PhD students in STEM fields at U.S. institutions or those who have completed their terminal degree within the past five years. If selected, Fellows will spend 12 weeks at the National Academies in Washington, DC learning about science and technology policy and the role that scientists and engineers play in advising the nation. Applications are due **August 20, 2025**.

In today's constrained funding environment, the Mirzayan Fellowship is exploring new ways to expand access to this transformative program. NAS members are invited to consider a new opportunity to sponsor a Fellow's participation in the program, in full or in part. Member sponsorships can help ensure the next generation has the same chance to engage with the National Academies at the intersection of science, engineering, medicine, and policy. **Watch a video** to learn more about the program's impact. If you are interested in sponsoring a Fellow, please **visit the donation webpage** or reach out to Andy Ho, NAS Director of Development (aho@nas.edu, 202-334-1854) with questions about making a donation.

Member News

Been in the news recently? Share your news with naseonews@nas.edu.

- » **Abhijit Banerjee** writes about cooking and eating and their connections to broader economic issues in a **monthly *Times of India* column**.
- » **Albert-László Barabási** was featured on a **TED Radio Hour episode** about finding joy and success as a late bloomer.
- » Read a **UC Davis profile** of **Andreas Bäumler** and his pioneering microbiota research.
- » **Thure Cerling** will receive the **2025 Penrose Medal** from the Geological Society of America for his work in low temperature geochemistry applied to geological problems.
- » **Jack Dongarra** discusses how supercomputing will evolve in a **Q&A with *Wired***.
- » **James Elser** authored a **PNAS commentary** on how small lakes are suffocating as winters warm.

» **David MacMillan** explains how his work in molecular chemistry could lead to a treatment for Alzheimer's disease within the next five years in **BBC**.
» Read a **new QnAs** with **Blake Meyers**, whose research has advanced understanding of the biological functions of small RNAs.

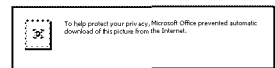
Biographical Memoirs

Ellis B. Cowling (Human Environmental Sciences)
Frans B M. de Waal (Anthropology)
George B. Field (Astronomy)
Harvey J. Karten (Systems Neuroscience)
Mary-Lou Pardue (Genetics)



National Academy of Sciences in the News

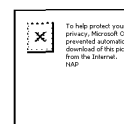
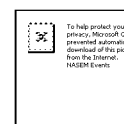
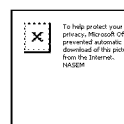
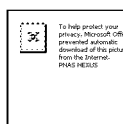
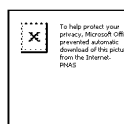
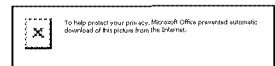
» ***The New York Times*: Fraudulent Scientific Papers Are Rapidly Increasing, Study Finds**
A **statistical analysis published in PNAS** find that the number of fake journal articles being churned out by "paper mills" is doubling every 1.5 years, threatening the scientific enterprise.



From the National Academies

Cyber Hard Problems

Cyber technologies underpin every facet of the economy and are critical for national security. Cyber and cyber-enabled systems are rapidly growing in both complexity and scale, and—despite significant progress—are outpacing the capacity to keep them safe, secure, and resilient to disruptions. Cyber hard problems—unsolved technical and research problems for which progress toward solution would have a significant impact on the practical security of cyber systems—are frequently caused or sustained by human or societal factors and misaligned incentives. These in turn are exacerbated by the continuing tremendous growth in the production and use of cyber technologies and their resulting near ubiquity in societally important systems and institutions. A **new report** builds off of the Cyber Hard Problem List originally developed for the Department of Homeland Security in 1996 and provides an update by identifying and describing current key hard problems for cyber resiliency. **Vinton Cerf** participated in the review of the report, which was overseen by **William Press**.





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From: John Christy [climateman60@gmail.com]
Sent: 8/8/2025 7:37:01 PM
To: Ross McKittrick [ross.mckittrick@gmail.com]
CC: Steven Koonin [steven.koonin@gmail.com]; Roy Spencer [roywspencer@hotmail.com]; Judith Curry [curry.judith@gmail.com]
Subject: Re: From the President: Endangerment Finding
Attachments: Saleska_2025_EF.pdf

All

This is from the University of Washington. The Endangerment Finding is the ruling they are focussed on. It seems to me they are determined to provide evidence of endangerment whereas we are supplying an evidenced-based analysis of climate science and impacts (and letting someone else determine the endangerment part.)

I've downloaded the Saleska paper (attached) - haven't looked at it yet.

John C.

----- Forwarded Message -----

Subject: Re: [Atmos-academic] DOE Report: A Critical Review of Impacts of Greenhouse Gas Emissions on the U.S. Climate

Date: Fri, 8 Aug 2025 09:54:28 -0700

Dear Colleagues,

As many of you are aware, the issue at hand is the EPA greenhouse gas "endangerment finding". "The finding by the EPA in 2009 that greenhouse gases do indeed endanger public health and welfare, referred to as the "Endangerment Finding," has served as the foundation for U.S. climate policymaking over the last decade and a half. It underpins regulations on greenhouse gas emissions from mobile and stationary sources, including new fossil fuel-fired power plants, passenger cars and trucks, and, in a 2016 update, certain aircraft." (Saleska et al. 2025)

The federal administration is attempting to repeal this finding, which sets the basis for regulation of greenhouse gasses as pollutants, and the DOE document is being put forward as the primary evidence. It matters that the evidence considered by the courts accurately represents our scientific knowledge at this time.

I encourage you to read this recently published article in AGU Advances (Saleska et al., 2025) about the current threat to the EPA endangerment finding co-authored by two of our faculty members who were involved in writing an amicus curiae to the Supreme Court for the original case in 2006. You can learn more in the article about the history of the case and why scientists were involved.

Yesterday the National Academies of Sciences, Engineering, and Medicine announced that they will issue their own review on the topic. You can submit peer-reviewed articles, white papers, technical reports, or other comments relevant to the committee's charge for their consideration until August 27th here.

On Fri, Aug 8, 2025 at 2:28 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

Irony given the number of people who accused us of misrepresenting "the science" but she misrepresents what we said. From our executive summary:

Both models and experience suggest that CO2-induced warming might be less damaging economically than commonly believed, and excessively aggressive mitigation policies could prove more detrimental than beneficial [Chapters 9, 10, Section 11.1]. Social Cost of Carbon estimates, which attempt to quantify the economic damage of CO2 emissions, are highly sensitive to their underlying assumptions and so provide limited independent information [Section 11.2].

From the Ch 11 summary

Mainstream climate economics has recognized that CO2-induced warming might have some negative economic effects, but they are too small to justify aggressive abatement policy and that trying to "stop" or cap global warming even at levels well above the Paris target would be worse than doing nothing. An influential study in 2012 suggested that global warming would harm growth in poor countries, but the finding has subsequently been found not to be robust. Studies that take full account of modeling uncertainties either find no evidence of a negative effect on global growth from CO2 emissions or find poor countries as likely to benefit as rich countries.

The criticism is of aggressive or excessively aggressive abatement policy. We also point out that if certain assumptions hold, then aggressive policy can be justified.

On Fri, Aug 8, 2025 at 2:42 PM Steven Koonin <steven.koonin@gmail.com> wrote:

See the first section in the email below from NAS President McNutt.

She mischaracterizes the CWG report. I don't think we anywhere argued "that the economic costs of regulation outweigh the potential benefits." Or am I mis-remembering :)

Do you think she even read the report?

SEK

Begin forwarded message:

From: NAS Members' Update <info@nationalacademies.org>

Date: August 8, 2025 at 14:32:12 EDT

To: Steven Koonin <koonin@stanford.edu>

Subject: From the President: Endangerment Finding

Reply-To: us8-6d9d5d2823-c30e00b9e2@inbound.mailchimpapp.net

[View this email in your browser](#)



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From the President: Endangerment Finding

Many members have expressed concern about the Environmental Protection Agency's proposal to rescind the endangerment finding that has provided the scientific basis for EPA's regulations of greenhouse gases over the last 15 years. The EPA's rationale relies heavily on a recent report by 5 researchers who question the prevailing scientific consensus on climate change and argue that the economic costs of regulation outweigh the potential benefits.

The deadline for public comment on this proposal is September 15. For this reason, the NRC is conducting a fast-track study to review



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the latest scientific evidence on whether greenhouse gas emissions endanger public health and welfare in the U.S. With partial funding from the Cicerone fund—to which so many members regularly contribute—we will launch this study immediately. Our goal is to assemble a balanced committee from academia, industry, and other sectors who are knowledgeable on the issues, open-minded to both the strengths and weaknesses of climate science, and who have avoided taking strong advocacy positions.

While the NRC has a large body of consensus reports on the topic of climate change, many are more than a decade old, and more recent reports do not specifically address aspects of scientific understanding and evidence that are directly relevant to the EPA's recent proposal. These earlier studies will provide input to this rapid response report but are an insufficient basis for a statement by the Academy presidents about the proposed EPA action.

I hope that NAS members, if asked to contribute to this effort, will do everything in their power to serve.

Protecting the Data of U.S. Statistical Agencies

In a statement, the presidents of the National Academy of Sciences and National Academy of Medicine urge federal leaders to respect and safeguard the integrity and objectivity of federal statistical agencies and the information they produce, which is vital to public policy and essential to the nation's economic well-being.

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NAS Selects Monica Feit as Executive Officer

The National Academy of Sciences has named Monica Feit as its next executive officer, effective October 4, 2025. In this role, Feit will oversee NAS core membership activities, including the election of its officers and members and their annual and regional meetings, as well as the offices of the NAS president, vice president, home secretary, and governing Council. Currently the executive director of the National Academies' health and medicine division, Feit has held various positions with the institution for more than 15 years. Feit will succeed NAS executive officer Ken Fulton,

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who will serve as senior advisor to the NAS President, full time until his retirement in January 2026 and then part time as needed, following more than five decades of service to the NAS. Read the press release.

2026 Mirzayan Fellowship: Call for Applications and Sponsorship Opportunity

Applications are now open for the 2026 Christine Mirzayan Science & Technology Policy Graduate Fellowship Program. Eligible applicants include current PhD students in STEM fields at U.S. institutions or those who have completed their terminal degree within the past five years. If selected, Fellows will spend 12 weeks at the National Academies in Washington, DC learning about science and technology policy and the role that scientists and engineers play in advising the nation. Applications are due **August 20, 2025**.

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In today's constrained funding environment, the Mirzayan Fellowship is exploring new ways to expand access to this transformative program. NAS members are invited to consider a new opportunity to sponsor a Fellow's participation in the program, in full or in part. Member sponsorships can help ensure the next generation has the same chance to engage with the National Academies at the intersection of science, engineering, medicine, and policy. Watch a video to learn more about the program's impact. If you are interested in sponsoring a Fellow, please visit the donation webpage or reach out to Andy Ho, NAS Director of Development (aho@nas.edu, 202-334-1854) with questions about making a donation.

Member News

Been in the news recently? Share your news with naseonews@nas.edu.

- » Abhijit Banerjee writes about cooking and eating and their connections to broader economic issues in a monthly *Times of India* column.
- » Albert-László Barabási was featured on a TED Radio Hour episode about finding joy and success as a late bloomer.
- » Read a UC Davis profile of Andreas Bäuml and his pioneering microbiota research.
- » Thure Cerling will receive the 2025 Penrose Medal from the Geological Society of America

for his work in low temperature geochemistry applied to geological problems.

» Jack Dongarra discusses how supercomputing will evolve in a Q&A with *Wired*.

» James Elser authored a PNAS commentary on how small lakes are suffocating as winters warm.

» David MacMillan explains how his work in molecular chemistry could lead to a treatment for Alzheimer's disease within the next five years in BBC.

» Read a new QnAs with Blake Meyers, whose research has advanced understanding of the biological functions of small RNAs.

Biographical Memoirs

Ellis B. Cowling (Human Environmental Sciences)

Frans B M. de Waal (Anthropology)

George B. Field (Astronomy)

Harvey J. Karten (Systems Neuroscience)

Mary-Lou Pardue (Genetics)

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National Academy of Sciences in the News

» *The New York Times*: Fraudulent Scientific Papers Are Rapidly Increasing, Study Finds

A statistical analysis published in PNAS find that the number of fake journal articles being churned out by "paper mills" is doubling every 1.5 years, threatening the scientific enterprise.

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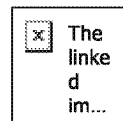
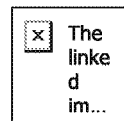
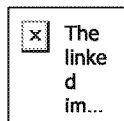
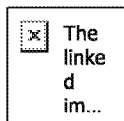
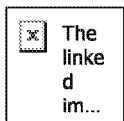
From the National Academies

Cyber Hard Problems

Cyber technologies underpin every facet of the economy and are critical for national security. Cyber and cyber-enabled systems are rapidly growing in both complexity and scale, and—despite significant progress—are outpacing the capacity to keep them safe, secure, and resilient to disruptions. Cyber hard problems—unsolved technical and research problems for which progress toward solution would have a significant impact on the practical security of cyber systems—are frequently caused or sustained by

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human or societal factors and misaligned incentives. These in turn are exacerbated by the continuing tremendous growth in the production and use of cyber technologies and their resulting near ubiquity in societally important systems and institutions. A new report builds off of the Cyber Hard Problem List originally developed for the Department of Homeland Security in 1996 and provides an update by identifying and describing current key hard problems for cyber resiliency. Vinton Cerf participated in the review of the report, which was overseen by William Press.





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Key Points:

- The US EPA's greenhouse gas endangerment finding is itself now endangered by the current Presidential Administration
- Scientists had a key role in bringing about the endangerment finding
- The science supporting the finding has only gotten stronger in the 16 years since the endangerment finding

Correspondence to:

S. R. Saleska and S. C. Wofsy,
saleska@arizona.edu;
wofsy@stanford.edu

Citation:

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Author Contributions:

Conceptualization: Scott R. Saleska, Steven C. Wofsy

Resources: David Battisti, William E. Easterling, Inez Fung, James E. Hansen, John Harte, Daniel Kirk-Davidoff, Jonathan T. Overpeck, John M. Wallace

Writing – original draft: Scott R. Saleska

Writing – review & editing: Scott R. Saleska, Steven C. Wofsy, David Battisti, William E. Easterling, Christopher Field, Inez Fung, James E. Hansen, John Harte, Daniel Kirk-Davidoff, Pamela A. Matson, James C. McWilliams, Jonathan T. Overpeck, Joellen Russell, John M. Wallace

What Is Endangered Now? Climate Science at the Crossroads

Scott R. Saleska¹, Steven C. Wofsy^{2,3}, David Battisti^{4,5}, William E. Easterling^{6,7}, Christopher Field⁸, Inez Fung^{9,10}, James E. Hansen¹¹, John Harte^{10,12}, Daniel Kirk-Davidoff¹³, Pamela A. Matson^{8,14}, James C. McWilliams¹⁵, Jonathan T. Overpeck¹⁶, Joellen Russell¹⁷, and John M. Wallace⁴

¹Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ, USA, ²School of Engineering and Applied Sciences, Harvard University, Cambridge, MA, USA, ³Department of Earth and Planetary Science, Harvard University, Cambridge, MA, USA, ⁴Department of Atmospheric and Climate Science, University of Washington, Seattle, WA, USA, ⁵University of Washington, Seattle, WA, USA, ⁶College of Earth and Mineral Sciences, Pennsylvania State University, University Park, PA, USA, ⁷Department of Geography and Earth System Science, Pennsylvania State University, University Park, PA, USA, ⁸Stanford Woods Institute for the Environment, Stanford University, Stanford, CA, USA, ⁹Department of Earth and Planetary Science, University of California Berkeley, Berkeley, CA, USA, ¹⁰Department of Environmental Science, Policy & Management, University of California Berkeley, Berkeley, CA, USA, ¹¹Climate Science, Awareness and Solutions Program, Columbia University Earth Institute, New York, NY, USA, ¹²Energy and Resources, University of California Berkeley, Berkeley, CA, USA, ¹³Atmospheric and Oceanic Sciences, University of Maryland, College Park, MD, USA, ¹⁴Department of Earth System Science, Emerita, Stanford University, Stanford, CA, USA, ¹⁵Department of Atmospheric and Oceanic Sciences, University of California Los Angeles, Los Angeles, CA, USA, ¹⁶School for Environment and Sustainability, University of Michigan, Ann Arbor, MI, USA, ¹⁷Geosciences Department, University of Arizona, Tucson, AZ, USA

Abstract The greenhouse gas “endangerment finding” of the U.S. Environmental Protection Agency (EPA), established in 2009 after a 2006 U.S. Supreme Court case (*Massachusetts vs. EPA*) in which we participated as amicus curiae (friends of the court), has become the basis for U.S. regulation of greenhouse gases in the years since. The current Administration of President Donald Trump is now seeking its repeal. Here, we review the role climate science played in that 2006 case, and how the scientific evidence that undergirds the endangerment finding has gotten stronger in the 16 years since. Finally, we consider what will be the fate of the endangerment finding—and indeed that of role of science in contributing to policy—in light of the current challenging environment for science in the U.S.

1. Introduction

After 16 years of using climate science to inform climate policy, U.S. federal policymakers are now poised to backtrack, with the U.S. Environmental Protection Agency (EPA) seeking to reverse its 2009 science-based finding (EPA, 2009) that carbon dioxide (CO₂) and other greenhouse gas emissions “endanger human health and welfare” (EPA, 2025).

The finding by the EPA in 2009 that greenhouse gases do indeed endanger public health and welfare, referred to as the “Endangerment Finding,” has served as the foundation for U.S. climate policymaking over the last decade and a half. It underpins regulations on greenhouse gas emissions from mobile and stationary sources, including new fossil fuel-fired power plants, passenger cars and trucks, and, in a 2016 update, certain aircraft (EPA, 2016).

But on March 12 of this year, EPA Administrator Lee Zeldin launched a drive to repudiate that finding, calling it the “holy grail of the climate change religion.” This, along with 30 other actions to reverse regulatory limits on pollution amount, in his view, to “the greatest and most consequential day of deregulation in U.S. history.” (EPA, 2025).

Here, we review the role that science and scientists have played in establishing the finding, including our role in the 2007 U.S. Supreme Court case on climate change that led directly to the endangerment finding. We then ask: Where do we go from here? What role will science play in shaping future climate policy in a world where U.S. leadership in science may be fundamentally weakened, at least in the short-term?

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2. Science at the Supreme Court: The Role of Science and Scientists in the Endangerment Finding

We are scientists from multiple U.S. institutions who study the earth's climate system. We are not policy practitioners, and we don't believe that science in the abstract implies that we should adopt particular policies. But we do strongly believe that we have an obligation to help society use scientific knowledge to advance the well-being of humanity by accurately communicating the state of science to policymakers and to the public, by correcting the record when required by the facts, and by advising our elected and appointed officials when our research or expertise is relevant to particular policy goals. It was precisely in this vein that we submitted a “friend of the court” *amicus* brief (Climate scientists, 2006) in the first U.S. Supreme Court case to recognize the science of climate change (Massachusetts et al. vs. EPA, decided in 2007). This case led directly to the adoption of the EPA's endangerment finding.

It is helpful to understand a bit about the Supreme Court case: in 2003, a group of states and environmental groups sued EPA, on the ground that the agency had violated the Clean Air Act by failing to regulate greenhouse gas emissions from new motor vehicles. EPA argued, among other reasons, that climate science was too uncertain to support regulations, relying upon a 2001 National Academy of Sciences report authored by several of us (Climate Change Science: An Analysis of Some of the Key Questions, NAS, 2001), as its sole authoritative source of scientific information. Although this NAS report unambiguously stated that it is virtually certain that greenhouse gas emissions from human activities cause global climate changes, EPA drew selectively from the Report to downplay this conclusion and instead highlighted the Report's statement that a “causal linkage between the buildup of greenhouse gases in the atmosphere and the observed climate changes during the 20th century cannot be unequivocally established.”

When Massachusetts and other states appealed EPA's regulatory denial, and the case eventually reached the Supreme Court, we submitted the *amicus* brief to correct what we saw as the government's fundamental misrepresentation of the 2001 NAS Report and to interpret, for the justices, the status of climate science and how it impacted EPA's duty to carry out Congress's directive under the Clean Air Act. The Act calls upon EPA to regulate the emissions of any air pollutants that “may reasonably be anticipated to endanger public health or welfare” (the “endangerment” standard).

In our brief, we explained the scientific data supporting the conclusion that global average temperature increases, and other associated climatic changes, were very likely to have been caused by humans and how the scientific record thus ought to trigger an EPA duty to regulate. The brief argued first, that EPA did not need “unequivocal” evidence to link human emissions to warming because the standard in law is precautionary, requiring only “reasonable anticipation of endangerment,” and second, that in our professional judgment as climate scientists, the evidence at the time more than sufficed to meet that standard.

The state of the science played an important role during oral argument at the Court, in part because our *amici* group included a majority of authors from the NAS (2001) report. Accordingly, when the lawyer for the Bush administration argued that EPA used NAS (2001) to assess uncertainty, Justice Stevens interrupted him to cite our brief, saying “I find it interesting that the scientists who worked on that report said there were a good many omissions that would have indicated that there wasn't nearly the uncertainty that the [EPA] described.”

In the end, the Court held that greenhouse gases did indeed constitute pollutants within the meaning of the Clean Air Act, and that EPA's decision not to regulate “rests on reasoning divorced from the statutory text... Nor can EPA avoid its statutory obligation by noting the uncertainty surrounding climate change... If the scientific uncertainty is so profound that it precludes EPA from making a reasoned judgment, it must say so.” The court sent EPA back to determine whether such emissions met the level of certainty required by the Act's regulatory trigger. Thus, the groundbreaking case of *Massachusetts v. EPA*, 549 U.S. 497 (2007) set the stage for EPA to consider, and to affirm in 2009, the endangerment finding.

In its 2009 endangerment finding, EPA relied most heavily upon the assessments of the U.S. Global Climate Research Program, the National Research Council, and the Intergovernmental Panel on Climate Change, concluding that this body of scientific evidence “compellingly” supported the endangerment finding. For endangerment of public health, it relied on evidence of highly likely increases in ambient ozone concentrations, occurrences of longer and hotter heat waves, and other extreme weather events such as hurricanes and floods.

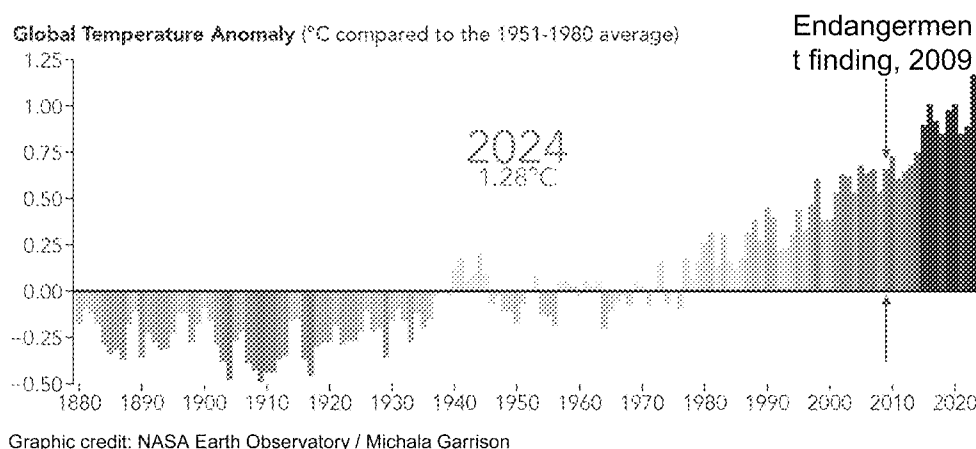


Figure 1. Global average surface temperature anomaly, 1880–2024 (degrees C, relative to the 1951–1980 average). The 2024 temperature anomaly of 1.28°C is close to twice that of 0.66°C in 2009, the year the endangerment finding was published. Source: Lenssen et al. (2024), as updated by GISTEMP Team (2025).

3. The State of the Science of Climate Change, 16 Years After the Endangerment Finding

Sixteen years later, the scientific evidence supporting the endangerment finding is even stronger, with zero countervailing evidence. Our *amicus* brief's predictions of future climate trends have all come true, some alarmingly faster than anticipated. For example.,

- *Global warming will continue.* Observations since 2009 confirm that the earth's net energy imbalance has approximately doubled. At least five climate metrics reveal that the most extreme years of the instrumental record have all been observed since the 2009 endangerment finding: (a) global surface temperature (the 12 warmest years on record are after 2009, Figure 1), (b) global ocean heat content (heat integrated down to 2000 m has been rising steadily since 2009, ORAS5, 2024), (c) arctic sea ice retreat (14 of the 16 lowest sea ice September minima have occurred after 2009, Copernicus, 2024b), (d) sea level rise (has accelerated since 2009, rising at 4.3 mm/yr during 2013–2023, compared to 2.1 mm/yr during 1993–2003, Copernicus, 2024a), and (e) ocean acidity increase (pH has continued to decline steadily, at -0.017 pH units per decade, Copernicus Marine Service, 2023).
- *Impacts directly related to public health and welfare will accelerate.* Observations show that the severity, extent, and/or frequency of multiple types of weather and climate-related extreme events are increasing, and impacting human health and welfare (USGCRP, 2023): heat-related deaths are rising, both in the U.S. and around the world (Romanello et al., 2024; Vicedo-Cabrera, 2021), woodland and forest fires in mediterranean climates, including the Western U.S., along with associated smoke events, are now more severe (Hagmann et al., 2021; USGCRP, 2023). Further, climate-enabled spread of disease has increased (Semenza et al., 2022), as have climate-related disruptions to agricultural productivity, both crop and livestock (FAO, 2015; Ortiz-Bobea et al., 2021).

In addition to observed climate change trends continuing as predicted, climate science has advanced. Particularly relevant for the strength of the endangerment finding, the science of attribution—the ability to attribute part of the extremeness of extreme events to the effects of climate change—has advanced significantly (Otto et al., 2024). Much more so than in 2009, we can now conclude with confidence that many climate and weather extreme events are more severe because of climate change. For example, the record-setting Pacific Northwest heat wave of 2021 was made about eight times more likely by greenhouse gas emissions (Leach et al., 2024). Absent mitigation, the future will be more dangerous than the past (Kemp et al., 2022).

4. Whither the Endangerment Finding?

In light of the accumulating evidence of the last 16 years, we strongly reiterate the conclusion stated in our Supreme Court *amicus* brief (Climate Scientists, 2006) that “in our professional opinion as climate scientists, the

evidence supporting such a determination [of reasonable anticipation of endangerment] is compelling.” The evidence supporting this conclusion is significantly stronger today than it was 16 years ago.

While we do not know how EPA might justify a decision to reverse its 2009 endangerment finding, we do know that the logic of the scientists' brief at the Supreme Court in 2006–2007 constitutes the strongest reason for why its repeal should not happen now. To undo the endangerment finding, EPA would normally have to show (through a multi-year rulemaking and comment process sufficient to stand up in court) that the scientific evidence does *not* support a finding that it is reasonable to anticipate danger to human health and welfare from climate change, or that U.S. emissions do not “cause or contribute to” that danger. U.S. CO₂ emissions have fallen ~20% since their peak in 2007, but US emissions are still the second largest in the world on an annual basis, after China, so they still mightily “contribute to” endangerment. As long as greenhouse gas emissions continue, the magnitude of climate change and its impacts will grow. Thus, EPA would have to show that it is *unreasonable* to anticipate danger to human health and welfare from climate change. (The administration has suggested that it might use the costs of regulating greenhouse gases as a reason to reverse the endangerment finding, but per the Court's opinion in *Massachusetts v. EPA*, an endangerment finding itself should not consider costs, because costs typically come into play later, in designing regulations that follow from that finding.) If, on the other hand, the endangerment finding is nonetheless repealed, it would seem to portend that science and scientific evidence will not guide U.S. climate policy in the coming years.

We are profoundly aware that we write at a time when science in the U.S. more broadly is facing an array of challenges. Even the basic expectation that policy-making decisions should be evidence-based and informed by science may not be assured in the future. But the scientific laws that govern our climate will continue to govern climate, no matter what rhetoric about “climate change religion” is asserted or which policies are adopted.

If science becomes more politicized, public support for science will decline, and its role in policy formation will diminish, with a consequential devastating and persistent impact on both scientific discovery and national policy, with negative impacts for our nation. A great nation requires the best science. More than ever, it is imperative that we apply our knowledge to create a thriving economy, a healthy population, and a strong society. That cannot be achieved if we simultaneously ignore the danger of ever-climbing concentrations of atmospheric CO₂ and other greenhouse gases while undermining the foundations of climate science itself.

Acknowledgments

We thank AGU Advances editor Eric Davidson for suggesting the idea of contributing this Commentary. We thank Kirsten Engel and Dan Galpern for review and insightful comments on an earlier version of the manuscript. We write this comment in acknowledgment and fond memory of our colleagues and 2006 amicus brief distinguished co-authors whose professional lives were dedicated to the advancement of science and to bringing the benefits of science to humanity: Eugenia Kalnay (1942–2024), formerly distinguished University Professor of Atmospheric and Oceanic Science, University of Maryland. Mario J. Molina (1943–2020), formerly Professor of Chemistry and Biochemistry at the University of California, San Diego, and co-recipient of the 1995 Nobel Prize in Chemistry (with F. Sherwood Rowland and Paul Crutzen) for the discovery that chlorofluorocarbons contribute to stratospheric ozone depletion. F. Sherwood Rowland (1927–2012), Bren Research Professor of Chemistry and Earth System Science at University of California, Irvine, and co-recipient of the 1995 Nobel Prize in Chemistry (with Mario Molina and Paul Crutzen) for the discovery that chlorofluorocarbons contribute to stratospheric ozone depletion.

Conflict of Interest

The authors declare no conflicts of interest relevant to this study.

Data Availability Statement

As a commentary, no original data was generated in the production of this article, and the data referred to in this article is generally available in publications cited herein.

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From: Roy Spencer <roywspencer@hotmail.com>
Sent: Thursday, July 31, 2025 3:27 PM
To: Ross McKitrick; Judith Curry; John Christy; Steven Koonin; Josh Loucks; Cohen, Seth; Fisher, Travis
Subject: Re: Fw: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

Ironic that no one cared when MY work was mischaracterized by the 97-Percenter's as being part of the 3%, even though by their criteria I was part of the 97% consensus.

I complained, but all they said was, "well, we put you in the 3 percent category".

The bias is rampant.

-Roy

From: Ross McKitrick <ross.mckitrick@gmail.com>
Sent: Thursday, July 31, 2025 11:27 AM
To: Roy W. Spencer <roywspencer@hotmail.com>; Judith Curry <curry.judith@gmail.com>; John Christy <climateman60@gmail.com>; Steven Koonin <steven.koonin@gmail.com>; Josh Loucks <loucksj14@gmail.com>; Cohen, Seth <seth.cohen@hq.doe.gov>; Fisher, Travis <travis.fisher@hq.doe.gov>
Subject: Fwd: Fw: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

John and I got this from Tim Vogelsang at MSU. Carbon Brief is contacting everyone whose work was cited trying to gather up claims of misrepresentation. As Tim notes, there is no option on the form for saying your work was correctly characterized.

From: Vogelsang, Timothy <tjv@msu.edu>
Sent: Thursday, July 31, 2025 12:19 PM
To: Ross McKitrick <rmckitri@uoguelph.ca>; John Christy <climateman60@gmail.com>
Subject: RE: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

CAUTION: This email originated from outside of the University of Guelph. Do not click links or open attachments unless you recognize the sender and know the content is safe. If in doubt, forward suspicious emails to IThelp@uoguelph.ca.

If you look at the pdf I was sent with the instructions, there is no option to report that someone's research has been correctly characterized. That's not a very scientific factchecking exercise, is it!

Tim

From: Ross McKitrick <rmckitri@uoguelph.ca>
Sent: Thursday, July 31, 2025 12:15 PM
To: Vogelsang, Timothy <tjv@msu.edu>; John Christy <climateman60@gmail.com>
Subject: Re: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

I've heard of Carbon Brief but only read snippets of their articles cited elsewhere. They seem to be heavily into promoting renewables.

It's interesting to watch the machine swing into gear. There is a public comment docket opening up and I expect there will be quite the avalanche of material submitted, which we will need to prepare responses to, all of which will form part of the public record. If the comments are substantive we'll readily make revisions. We responded to a lot of comments from the internal DoE staff during the pre-publication review stage. But some of the most hostile comments didn't provide any data or citations in support so we couldn't do anything with them.

Ross

Dr. Ross McKittrick
Professor of Economics
Department of Economics and Finance
rossmckittrick.com



University of Guelph | Guelph ON Canada N1G 3P9

From: Vogelsang, Timothy <tjv@msu.edu>
Sent: Thursday, July 31, 2025 12:02 PM
To: Ross McKittrick <rmckitri@uoguelph.ca>; John Christy <climateman60@gmail.com>
Subject: FW: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

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Ross and John,

I just got this email. Maybe you know about this group. I'm sure this is just the tip of the iceberg of pushback coming.

Tim

From: Leo Hickman <leo.hickman@carbonbrief.org>
Sent: Thursday, July 31, 2025 11:49 AM
To: Leo Hickman <leo.hickman@carbonbrief.org>
Subject: Carbon Brief factcheck - your study has been cited in new US DoE 'critical review'

Hello,

I'm contacting you because we have noticed that at least one of your studies has been cited in a new report published this week by the US Dept of Energy titled, "A Critical Review of Impacts of Greenhouse Gas Emissions on the U.S. Climate."

A number of scientists cited in the report have already publicly highlighted that their findings have been falsely or misleadingly characterised. It seems that the report is intended to be used as scientific justification by the Trump administration in its efforts to revoke the US Environmental Protection Agency's "endangerment finding" on greenhouse gases.

Carbon Brief is now seeking your help to assess whether your own study, or indeed your area(s) of expertise more widely, have been mischaracterised in the report. This is part of a wider 'crowdsourced' fact-checking effort we are now convening to draw on inputs from experts in their respective fields.

I have attached a PDF with some instructions on how you can participate with your own insights and reflections, should you wish. (The instructions include ways to do this anonymously and securely, if that is your preference.)

Additionally, if you know of a colleague or co-author who might wish to participate, please feel free to forward this email to them.

Our deadline for submissions is Monday 11 August 2025 - 0900 GMT.

Many thanks in advance.

Best wishes, Leo

--

Leo Hickman

Editor, [Carbon Brief](#)

Phone: + 44 (0) 7731 403979

Social: [Twitter](#); [BlueSky](#); [LinkedIn](#)

Web: www.carbonbrief.org

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From: Ross McKittrick <ross.mckitrick@gmail.com>
Sent: Thursday, August 7, 2025 5:22 PM
To: Steven Koonin
Cc: John Christy; Judith Curry; Roy W. Spencer
Subject: Re: FW: Nature article on economic damage from climate change under review

Yes, I saw the article yesterday. One of our DoE reviewers had asked us to cite the Kotz et al. study and in my response I pointed out that it was subject to some ongoing critiques about data and methodology errors so it was premature to rely on it. The critique just published by Hsiang and coauthors was pretty brutal. Much of the Kotz result came from including erroneous outlier data from a single country (Uzbekistan) and when it was removed the results collapsed. There were other problems as well. The fact that the NGFS people relied on it so uncritically is shameful.

I have a new paper forthcoming in Climate Change Economics with a former PhD student that uses two newly-constructed global data bases and adds to the evidence that warming has only small temporary effects on income (that are + or - depending on the location) and no net impacts on growth.

<https://www.rossmckitrick.com/uploads/4/8/0/8/4808045/cc.and.growth.accepted.version.pdf>

I didn't cite it in CWG25 because it hadn't been accepted yet but if needed it's fair game now. I sent it to Richard Tol who's been criticizing our report on his blog but haven't heard back from him.

On Thu, Aug 7, 2025 at 5:01 PM Steven Koonin <steven.koonin@gmail.com> wrote:

Ross might already know about this, but it was interesting news to me - SEK

From: Greg Hopper <Greg.Hopper@bpi.com>
Sent: Thursday, August 7, 2025 4:26 PM
To: Steven Koonin <koonin@stanford.edu>
Subject: Nature article on economic damage from climate change under review

Hi Steven,

I really enjoyed reading your recent DOE report (and your book) and in particular the section of the report on the effect of climate change on economic growth.

I don't know if you saw the WaPo article yesterday <https://www.washingtonpost.com/climate-environment/2025/08/06/nature-study-flawed-climate-damages/> that reported on the problems with a paper in Nature <https://www.nature.com/articles/s41586-024-07219-0> from last year that claimed economic damage from climate change is very large. As the WaPo reported, there was a large data error discovered by your Stanford colleague Solomon Hsiang and some co-authors. Hsiang et al, in a "Matters Arising" showed that when the data problem is fixed and uncertainty accounted for, a good bit of the result goes away.

In December last year, I published a research paper at the Bank Policy Institute, where I'm a senior fellow, that raised very serious statistical questions about the Nature model. My criticisms were not high level points easily dismissed. I took a very deep dive into their model, re-estimating and re-simulating it under alternative assumptions. I sent my analysis to the corresponding author of the paper. She never responded. Then I sent the paper to the Nature editors, asking them to look at my criticisms. I offered to do a formal submission according to their process if they wanted. The editors never answered me. The points I raised are different from Hsiang et al but neither the authors nor Nature responded to them.

The authors of the Nature article have a new proposed version of the paper up now in which they fixed the data error but then they changed the model, miraculously finding pretty much the same results. They seem to be very obviously targeting the answer. If the Nature editors let them do this, I think it's a scandal.

I've attached my analysis from last December FYI.

Greg Hopper

<https://bpi.com/people/greg-hopper/>

From: Ross McKittrick [ross.mckittrick@gmail.com]
Sent: 7/30/2025 5:55:05 PM
To: William Happer [happer@princeton.edu]
CC: Morano@climatedepot.com; Spencer, Roy W. [roywspencer@hotmail.com]; Steve Koonin [steven.koonin@gmail.com]; Judith Curry [curry.judith@gmail.com]
Subject: Re: FYI: Richard Tol not happy with his citations being in DOE climate assessment Fwd: Is climate change dangerous?

I re-read his literature meta-analysis. His objections to our citation are odd, I think the use of his paper is legit. But he is very mercurial. Even in his lit review he is prone to very dismissive and pejorative comments towards papers he doesn't like. He has a reputation as being very prickly and combative in print though in person we get along quite well.

On Wed, Jul 30, 2025 at 1:32 PM William Happer <happer@princeton.edu> wrote:

Mr. Tol's scientific ignorance is breathtaking. He would not last long if his lungs were subject to the real pollutants, SO₂ and NO₂ that he likens to CO₂. There is clear geological evidence that life on Earth has flourished with much higher atmospheric concentrations of CO₂ than today during most of the last 500 million years. The only clear consequence of more CO₂ has been a greening of the Earth. The excellent DOE report clearly demonstrates that there have no alarming changes in climate or weather during the last century of increasing CO₂. And this is hardly surprising since CO₂ is such a puny greenhouse gas. "Instantaneously" doubling CO₂ concentrations would only reduce the cooling infrared radiation of Earth to space by about 1%. But then Tol has made his living on climate alarmism, so he and many other will not "go gentle into that good night."

From: Marc Morano <marcmorano@gmail.com>
Sent: Wednesday, July 30, 2025 12:57 PM
To: Spencer, Roy W. <roywspencer@hotmail.com>; McKittrick, Ross <ross.mckittrick@gmail.com>; Steve Koonin <steven.koonin@gmail.com>; William Happer <happer@princeton.edu>; Judith Curry <curry.judith@gmail.com>
Subject: FYI: Richard Tol not happy with his citations being in DOE climate assessment Fwd: Is climate change dangerous?

----- Forwarded message -----

From: Richard Tol from Tol Tales <richardt@substack.com>
Date: Wed, Jul 30, 2025 at 12:30 PM
Subject: Is climate change dangerous?
To: <marcmorano@gmail.com>

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Is climate change dangerous?

READ IN APP 

Yes, it is. There is a long debate in the literature about the extent of the impacts of climate change but no one doubts that people will get hurt. The uncertainty about climate change impacts is large, which in itself is a reason to worry, and most would say the uncertainty is skewed the wrong way: Negative surprises are more likely than positive surprises (of equal size). If President Obama had asked me to write his Endangerment Finding I would have given him two words: “well duh”.

The Trump Administration wants to overturn this. The EPA published a legal document. The EPA argues that “GHGs [...] impact[] public health and welfare only indirectly and not by its mere presence in the ambient air”. That is true. Carbon dioxide (CO₂) is not toxic. Your lungs are full of it. We worry about CO₂ because it changes the climate, an indirect effect.

We often worry about indirect effects. As Einstein noted, it is not the fall that kills you, it is the sudden stop. Pushing someone off a building only indirectly kills them.

The EPA does not take issue with characterizing nitrogen dioxide (NO₂) and sulphur dioxide (SO₂) as air pollutants, even though these gases too affect public health and welfare only indirectly, after being transformed into nitric acid (HNO₃) and sulphuric acid (H₂SO₄), respectively.

My legally trained friends tell me that the law is impartial. If a line of argument holds for two substances (NO₂ and SO₂) then it also holds for a third (CO₂).

The DoE published a scientific report in support of the EPA’s legal argument. I am cited 3 times. First, the authors write that “Tol (2017) estimates that the private benefit of carbon is large relative to the social cost.” This paper was never published in a peer-reviewed journal and is therefore not admissible by the rules of the US government. The paper was peer-reviewed and rejected, because my private benefit is an average whereas the social cost is a marginal. The two cannot be compared (unless you make a ridiculous assumption about linearity). I still hope to fix the paper one day. As it stands, however, the comparison is wrong.

The authors further write that “[a]n influential study in 2012 suggested that global warming would harm growth in poor countries but the finding has subsequently been found not to be robust (Tol 2024). Studies that take full account of modeling uncertainties either find no evidence of a negative effect on global growth from CO2 emissions or find poor countries as likely to benefit from it as rich countries.” The authors did not read the paper carefully. The Dell/Jones/Olken result is indeed not robust: Later studies found that the differentiation is between hot and cold countries rather than rich and poor ones; or that everyone is affected equally.

The second sentence is wrong. The authors refer to “studies” but without references. Tol (2024) finds that the then available studies jointly point to a negative impact of climate change on global economic growth. My less systematic reading of the literature since has not led me to change my mind.

Their conclusion that “poor countries” are “likely to benefit” is again not backed up with references. Tol (2024), the only reference in the paragraph, concludes the opposite.

The third citation is to FUND in the section on the social cost of carbon. The literature is vast. I counted 446 papers with estimates. There are numerous commentaries; and two handfulls of meta-analyses. Instead, the authors wrote their own review, which omits the most influential papers and misses key insights. Cherry-picking may be a better term than review.

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Marc Morano

202-536-5052

Morano@ClimateDepot.com

@ClimateDepot

www.ClimateDepot.com

From: Ross McKittrick <ross.mckitrick@gmail.com>
Sent: Thursday, May 1, 2025 10:32 AM
To: Judith Curry
Cc: Travis Fisher; John Christy; Roy W. Spencer; Steven Koonin
Subject: Re: Global Greening

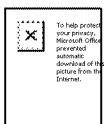
Thanks Judy. I like the reorganization. I'd like to keep the paragraph on the Haverd et al study because it ties in with the later SCC material, particularly Dayaratna's and my 2023 paper. Which I had forgotten to include in last night's version but is added in to the draft now posted.

I'm ok to get rid of the crop stuff although for people who've never heard that CO2 helps plants it might be surprising.

On Wed, Apr 30, 2025 at 7:25 PM Judith Curry <curry.judith@gmail.com> wrote:
Hi Ross, some good material here. My comments are attached.

Two structural recommendations:
move section 2.4 on greening up front to section 2.1
Delete section 2.3 (individual crops)

On Wed, Apr 30, 2025 at 1:02 PM Ross McKittrick <ross.mckitrick@gmail.com> wrote:
Hi everyone
Here is my draft of CO2 and greening. There is a bit of overlap with the brief chapter on climate and agriculture, but it can be tidied up later.
I've put this and Roy's alkaline ocean chapter in the 00.Report Draft folder.



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Judith Curry [curry.judith@gmail.com]
Sent: 4/30/2025 11:25:15 PM
To: Ross McKittrick [ross.mckittrick@gmail.com]
CC: Travis Fisher [travis.scott.fisher@gmail.com]; John Christy [climatemanager60@gmail.com]; Roy W. Spencer [roywspencer@hotmail.com]; Steven Koonin [steven.koonin@googlemail.com]
Subject: Re: Global Greening
Attachments: 2 CO2 and greening JC.docx

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--



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

2 CO₂ fertilization and global greening

MOVED SECTION

2.1 CO₂ and global greening

“Greening” refers to an increase in the total amount of the Earth’s surface covered in plants. The main measure of greening is “Leaf Area Index” or LAI as measured by satellite. Many studies over the past decade have confirmed a global greening pattern (rising LAI) attributable to rising CO₂ levels. Zhu et al. (2016) was one of the first studies to report that global greening was detectable from space using satellite sensors. On data spanning 1982 to 2011 they detected greening over 25-50% of the Earth versus browning over only 4%, and they attributed 70% of the greening to rising CO₂ levels (see Figure 2.3).

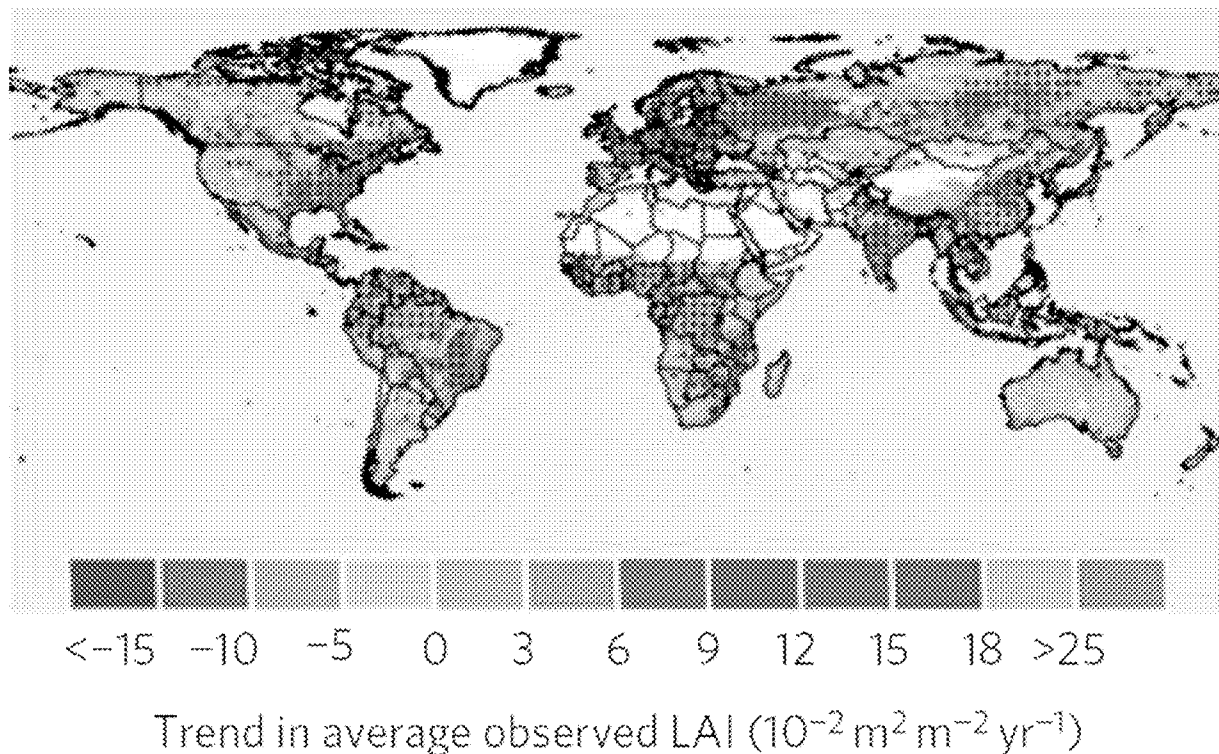


Figure 2.3: Trends in average Leaf Area Index (LAI). Source: Zhu et al. 2016 Figure 3.

Zheng (2017) confirmed the pattern, noting that greening over 30 years had added 8% to global leaf area and that greening was mitigating warming. Greening has been observed globally but Chen et al. (2019) noted that China and India were taking particular advantage of it though land management changes. Thus while China accounts for only 6.6% of global vegetated area it accounts for 25% of global net increase in LAI. Piao et al. (2020) noted that greening was even observable in the Arctic.

While plant models predict increases in photosynthesis should be observed in response to rising CO₂, Haverd et al. (2020) reported that observed CO₂ fertilization rate was nearly double what models had predicted. That is, CO₂ fertilization had driven an increase in observed global photosynthesis by 30% since 1900, versus 17% predicted by plant models. Among other things this indicates that global models of the socioeconomic impacts of climate change have likely understated the benefits to crops

~~and agriculture from rising CO₂. The connection between CO₂ fertilization and climate policy will be discussed in Chapter XX.~~

Finally, Chen et al. surveyed claims that greening had slowed down since 2000 due to drought stress. They found instead that claims of slowed greening could be attributed to faulty satellite sensors. Once the data were corrected they found greening was accelerating over 55% of the world while browning was accelerating over only 7% of the world. Overall the greening trend was continuing with no evidence of slowdown, and CO₂ fertilization remained the dominant driver

2.2 Photosynthesis and CO₂ levels

A key direct effect of adding CO₂ to the atmosphere is its positive effect on plant life via enhancement of photosynthesis and improvement to plant water use efficiency.

The term *photosynthesis* describes the process by which plants build biomass. The process requires carbon dioxide (CO₂), water (H₂O), and light. The plant enzyme responsible for photosynthesis is called Ribulose-1,5-bisphosphate-carboxylase/oxygenase or “Rubisco”. Photosynthesis is initiated when CO₂ is available at the surface of the RuBisCo enzyme where it is converted to a molecule with 3 carbon atoms and thereafter incorporated into plant mass, which is referred to as the C3 process.

Rubisco is estimated to have evolved about 3 billion years ago. Over geological time the Earth’s atmospheric CO₂ levels were usually much higher than they are today. About 400 million years ago CO₂ levels were an estimated 2,000-4,000 ppm and were at or above 1,000 ppm for much of the interval from 200 to 50 million years ago (Bernier 2006, Judd et al. 2024). Over the past 35 million years the level of atmospheric CO₂ has been steadily declining. During glaciations levels have fallen as low as 170 ppm (Gerhart and Ward 2010). In response to low-CO₂ conditions some plants evolved another photosynthetic pathway called C4, in which CO₂ is concentrated in the vicinity of Rubisco allowing for the C3 process to function more efficiently. For agricultural purposes the plant categories are:

- C3: rice, wheat, soybeans and most other crops
- C4: maize (corn), sugar cane, millet, sorghum

Had atmospheric CO₂ levels continued declining, plant growth rates would have declined and eventually ceased. Below 180 ppm many C3 species experience growth rate reductions on the order of 40-60% compared to their growth rates at 350 ppm (Gerhart and Ward 2010). C3 plants have been observed under experimental conditions to stop growing altogether at levels between 60—140 ppm CO₂. Some C4 plants are still able to grow at levels even as low as 10 ppm, albeit very slowly (Gerhart and Ward 2010).

Currently, CO₂ levels are about 420 ppm, up from 280 ppm in the early 1800s. The positive response of plants to extra CO₂ is illustrated in Figure 1 which is reproduced from Gerhart and Ward (2010). It shows the growth effect of CO₂ on Velvetleaf (*Abutilon theophrasti*) seedlings over 14 days under controlled conditions where only the CO₂ exposure is varied. The gains exhibited from increasing CO₂ from 150 ppm to 350 ppm continue under a further doubling to 700 ppm.

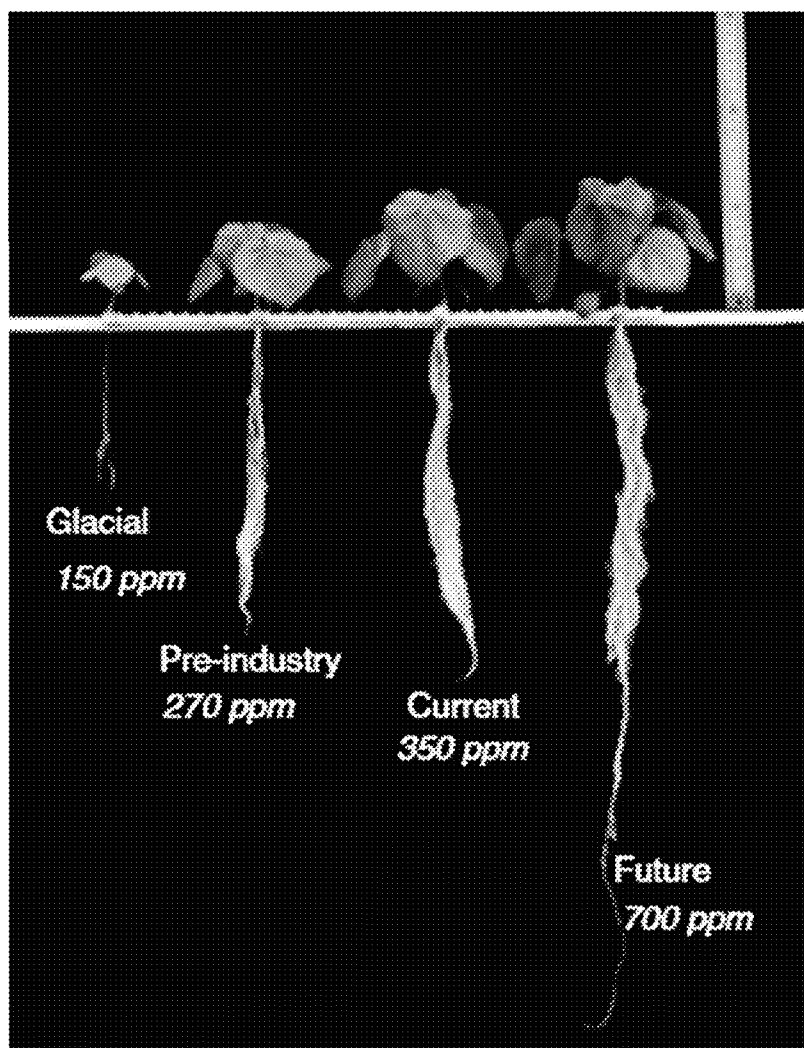


Figure 2.1: growth of *Abutilon theophrasti* after 14 days under identical conditions but for the indicated variations in CO₂ levels. Source: Gerhart and Ward (2010).

Over the past 60+ years there have been tens of thousands of studies on the response of plants to rising CO₂ levels. The overwhelming theme is that plants, especially C3 plants, benefit from extra CO₂. There are two mechanisms by which CO₂ confers a growth benefit:

- Enhanced photosynthesis via the metabolic pathways described above.
- Increased water use efficiency. This arises because plants draw in CO₂ by opening the stomata (pores) on the leaf surface. When CO₂ is scarce the stomata must be kept wide open for long periods, which allows water to evaporate away. Under enriched CO₂ conditions the stomata are closed for longer periods helping the plant retain water longer, thereby increasing water use efficiency.

One of the ways in which scientists have studied the effects of CO₂ enrichment is through “free air enrichment experiment” or FACE plots, in which small chimneys are placed in fields surrounding plants and the growth response to elevated CO₂ under varying weather conditions are recorded. Ainsworth and Long (2021) summarize results from about 250 such studies. They conclude:

- “Across 186 independent studies of 18 C3 crops, elevation of [CO₂] by ca. 200 ppm caused a ca. 18% increase in yield under non-stress conditions.”
- “Legumes and root crops showed a greater increase and cereals less. Nitrogen deficiency reduced the average increase to 10%, as did warming by ca. 2°C.”

The authors reported that C4 plants mainly exhibited benefits during drought conditions. However additional evidence on corn growth under enhanced CO₂ levels will be provided below.

2.2 CO₂ and key global food crops - I DON'T THINK THIS SECTION IS NEEDED

Rice

Lv (2020) analyzed experimental studies done on conventional rice plants in Japan and China. They found that the type of cultivar was a determining factor in quantifying the amount of response displayed, but all cultivar types showed positive yield response to elevated CO₂ levels. An additional 200 ppm CO₂ raised rice yields by 13.5%-32.8% for three common rice cultivars. A similar meta-analysis synthesis (Hu, 2021) was done for all available FACE studies on rice. On average, elevated CO₂ enhanced rice yields by 16.2% and improved their leaf photosynthesis. Hybrid rice displayed a greater yield enhancement (24.7%) than conventional rice (14.2%). The synthesis also revealed that yield response to elevated CO₂ was constrained by changes in nitrogen availability and temperatures. Ainsworth and Long (2021) argued that if farmers are careful in choosing the rice variety with the highest yield potential, they will show as much as 35% yield increase from an extra 200 ppm CO₂ compared to 14% without adaptation.

Potatoes

Lee (2020) grew potato plants under elevated CO₂ concentration and reported they “yielded a distinct increase in growth and development and canopy net photosynthetic rate during tuber initiation and bulking. Consequently, biomass and canopy net photosynthesis increased, and tuber yield increased by 20.3%. The CO₂Science.org website reports on 33 published experiments between 1988 and 2019 exposing potatoes to enriched CO₂ levels. Converted to a common +300ppm scale the average photosynthesis rate change was +50.3 percent.

Soybean

Studies on the impact of elevated CO₂ on Soybean (*Glycine max* (L.) Merr.) plants in the water-deficient region of Huang-Huai-Hai Plain, China, showed that elevated CO₂ concentrations resulted in improved photosynthesis rate, water use efficiency and growth (Li, 2013) under both normal conditions and drought conditions. The CO₂Science.org website reports on 108 published experiments between 1985 and 2019 exposing soybean to enriched CO₂ levels. Converted to a +300ppm common scale the average growth benefit was +50.9 percent. In addition there were 10 studies reporting on +600 ppm CO₂ enrichment, resulting in an average increase in photosynthesis of 90.3%.

Maize (corn)

The CO₂Science.org website reports on 28 published experiments between 1983 and 2018 exposing corn (*Zea mays* L.) to enriched CO₂ levels. Converted to a +300ppm common scale the average growth benefit was +23.7 percent. Corn also benefits from increased drought tolerance under elevated CO₂. An experimental study (Allen Jr, 2011) exposed plants to water stress conditions in sunlit controlled-

environment chambers at 360 ppm (ambient) and 720 ppm (elevated) CO₂. The drought stress caused a 41% loss of growth under ambient CO₂ but only a 13% loss under elevated CO₂.

Wheat

The CO2Science.org website reports on 92 published experiments between 1983 and 2020 exposing common wheat (*Triticum aestivum* L.) to enriched CO₂ levels. Converted to a +300ppm common scale the average growth benefit was +67.6 percent. Blandino (2020) measured the yield as well as nutritional quality of an “improver” hybrid wheat variety and its parents under elevated CO₂ levels (+166 ppm). They reported a grain yield increase of +16% but a 7% decrease in grain protein levels. But they found that the food quality of different wheat varieties responded differently to elevated CO₂ levels, so that with proper varietal selection end-users can select wheat types that best take advantage of the elevated CO₂.

Coffee

The CO2Science.org website reports on 18 published experiments between 2013 and 2020 exposing coffee (*Coffea arabica*) to enriched CO₂ levels. Converted to a +300ppm common scale the average growth benefit was +110.9 percent. To forecast the future impact of climate on coffee yields, Verhage (2017) analyzed yield data over 1989 to 2013 from 42 municipalities in Brazil. The study found that “yield losses due to high air temperatures and water deficit will increase, while losses due to frost will decrease. Nevertheless, extra losses are offset by the CO₂ fertilization effect, resulting in a net increase of the average Brazilian Arabica coffee yield of 0.8% to 1.48 t ha⁻¹ in 2040-2070”.

Specific effects of climate change on US agriculture will be reviewed in Chapter XX.

2.3 Rising CO₂ and crop water use efficiency

Deryng et al. (2016) surveyed evidence on crop water productivity (CWP), i.e. yield per unit of water used, drawing attention to the potential for CO₂ both to enhance photosynthesis and reduce leaf-level transpiration (water loss during leaf respiration). They surveyed all available FACE data on crop yield changes for Maize (corn), Wheat, Rice and Soybean, and combined it with crop model data simulating yield responses as of 2080 under the extreme RCP8.5 scenario in four growing regions (Tropics, Arid, Temperate and Cold) each of which were split into rainfed and irrigated sub-regions. In every region they reported that models without CO₂ fertilization predicted CWP losses but CO₂ fertilization more than offset them and once it was taken into account all regions showed a net CWP gain. Deryng et al (2016) also reported that negative impacts on wheat and soybean yields from what?? were fully offset by CWP gains, and mitigated by up to 90% for rice and 60% for maize.

I don't think the figure is needed or particularly useful?

Figure 2.2 shows their Deryng et al.'s results. The gray bars report yield changes under warming alone and the green bars show the effects of warming after accounting for the CO₂ fertilization effect.



Figure 2.2: mean yield changes under RCP8.5 as of 2080 without CO₂ fertilization (gray) and with CO₂ fertilization (green). Data from Deryng et al. (2016).

Similar to this, Cheng et al. (2017) noted that increased global plant growth from 1982 to 2011 due to rising CO₂ uptake was accompanied by such large gains in CWP that despite the extra biomass global water use by plants had not increased.

Deryng et al. (2016) assumed that climate change would “exacerbate water scarcity”. It is noteworthy that while models predict drylands will expand under climate warming, current data show the opposite: greening is happening even in arid areas. Zhang et al. (2014) report that due to increased CO₂ levels “increasing aridity in drylands won’t lead to a general loss of vegetation productivity”; increased desertification will happen in at most 4% of currently arid areas.

2.5 Concealment of CO₂ fertilization benefits in IPCC Reports

If CO₂ emissions were discovered to be causing global crop declines and regional browning we would almost certainly have seen it discussed prominently in IPCC reports, and indeed it likely would have been the subject of its own chapter in an Assessment Report if not an IPCC Special Report on its own. By contrast the IPCC has been almost silent on the topic of global greening.

The topic is briefly acknowledged in a few places in the body of the IPCC 6th Assessment Report but is omitted in all Summary documents. Based on word searches here is what the most recent IPCC Summary documents (AR6) had to say about it:

Working Group I Summary for Policymakers: No mention.

~~Working Group I Technical Summary: No mention of greening. CO₂ fertilization mentioned twice: as a contributor via plant growth to the land carbon sink and as a contributor to the increased amplitude of the seasonal CO₂ cycle.~~

~~Working Group II Summary for Policymakers: No mention of greening except the observation that adding forest cover to cities can locally reduce temperatures. No mention of CO₂ fertilization.~~

~~Working Group II Technical Summary: No mention.~~

~~AR6 Synthesis Report: No mention.~~

~~AR6 Summary of Synthesis Report: (called the “Longer Report”): No mention.~~

The topic is briefly acknowledged in a few places in the body of the IPCC 6th Assessment Report but is omitted in all Summary documents.

Section 2.3.4.3.3 of the AR6 Working Group I report is titled “global greening and browning.” It points out that the IPCC Special Report on Climate Change and Land had concluded with high confidence that greening had increased globally over the past 2-3 decades. It then discusses the various estimate of greening trends, notes that there are variations in the estimates among data sets and then says that while they have high confidence greening has occurred, they have low confidence in the magnitude of the trend. There are also brief mentions of CO₂ fertilization effects and improvements in water use efficiency in a few other chapters in the AR6 Working Groups I and II Reports. ~~But as noted, despite the volume of supporting evidence, news about global greening, improved plant water use efficiency and gains in crop production is omitted from the Summaries for Policymakers.~~

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From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Wednesday, May 7, 2025 11:38 AM
To: Judith Curry
Cc: Roy Spencer; Steven Koonin; John Christy; Ross McKittrick
Subject: Re: Glossary

I'd be happy to take on the next version of the glossary. You don't need a PhD to do that, and I'm happy to take anything like that off your hands!

On Wed, May 7, 2025 at 10:31 AM Judith Curry <curry.judith@gmail.com> wrote:
thx for doing this. There are alot of acronyms used in the various chapters that should be included also

On Wed, May 7, 2025 at 3:45 AM Roy Spencer <roywspencer@hotmail.com> wrote:
Attached is my first cut at a glossary, 64 terms so far based upon my reading of the chapters.

I've omitted obvious things like EPA, CO2, NOAA, NASA...

I'm sure I missed a few terms, and feel free to make edits.

Of course, this could all wait until everything else is completed.

-Roy

From: Steven Koonin <steven.koonin@gmail.com>
Sent: Tuesday, May 6, 2025 9:02 PM
To: John Christy <climateman60@gmail.com>
Cc: Ross McKittrick <ross.mckittrick@gmail.com>; Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>
Subject: Re: Ch 8 Extreme weather

I was expecting to read/comment/edit Chapter 8 tomorrow (Wednesday), so I'll use this version. Roy, if you beat me to a summary, that's fine, else I'll take it on.

John, do decouple for at least a few days. I've made the mistake of not doing so on a few vacations, with great regrets afterward.

Steven Koonin

On May 6, 2025, at 21:53, John Christy <climateman60@gmail.com> wrote:

All

Here is a cleaned up version of chapter 8 which you will likely not see until 7 May, so that is the date.

My preference is for someone to read the thing and write the summary (8.4) based upon what a fresh set of eyes would conclude. Steve? Roy?

Ross. The panel charts of the individual station precipitation take up a lot of real estate and I think the value per acre is low. Since you calculated 3 statistics for each station, could you craft a bar chart or something to show that result? You would then have 9 charts, one for each of the 3 statistics and one each of the three regions. The nine charts may be panelized and fit on one plot. I know for us it's important for people to see the actual data (which is why I had those colored bar charts - now monochromatic), but it may be overkill for this document.

As to one of the statistics, I believe 3-day totals will be more meaningful and accurate than 1-day totals. I could send you a file of the heaviest 3-day total for each station and each year and you can do the analysis from there.

I especially like the way you parsed the Sidebar and I hope smart people will finally understand that when dealing with climate, our sample is pathetically small from which to draw hard conclusions.

I also enjoyed the added words on LTP. In fact do you have a few sentences that expand that a little to talk about the erratic nature of precipitation (spatial and temporal) in fancy statistical terms which means finding statistical significance in such a variable is a tough job?

I redid the number-of-event bar charts - all one color now.

I reran the Heatwave results to use 6-day periods as did NCA5. NCA5 was slick though. By choosing 1961-90 their background climatology was cold relative to decades before and since, so that results outside of those 30 years would produce a lot of days that exceed the percentile threshold. Then in the urban heatwave website, they started in 1960, assuring a result that more temps would exceed the threshold in post-1990 years.

That's all I've got.

Aloha

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

<8 Extreme weather.JRC.May07.docx>

On May 6, 2025, at 5:25 PM, John Christy <climateman60@gmail.com> wrote:

Steve

As Ross notes, the precipitation section is simply an update of our 2019 paper. The daily temperature work from the supplemented USHCN records is in a paper under review (but I suspect will have difficulty being accepted). The data are from the official USHCN site with my supplements adding about 10 percent to cover the missing data. There are about 41 million temperatures here, so I added about 4 million. Thus the results are dominated by publically-available data for others to check. If I get the go-ahead for publication, I can put the complete datafiles on a server for anyone to use.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 6, 2025, at 3:48 PM, Ross McKittrick
<ross.mckittrick@gmail.com> wrote:

The underlying analysis is all from John's and my Journal of Hydrology paper for which the code is already online. John updated and expanded the data sets and I ran them through the same code.

On Tue, May 6, 2025 at 4:41 PM Steven Koonin
<steven.koonin@gmail.com> wrote:

A thought about the analysis of long-term CONUS data, which as John knows I like very much:

If some (most?) of this work is as-yet unpublished in a peer-reviewed journal, I'd think you've got to make the expanded and in-filled database (and analysis code?) publicly accessible so that the work can be checked. Are you prepared to do that (at least for the "final", if not the "draft")?

SEK

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Tuesday, May 6, 2025 1:05 PM
To: John Christy <climateman60@gmail.com>
Cc: Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Steven Koonin <steven.koonin@googlemail.com>
Subject: Re: Ch 8 Extreme weather

Here's another edition of Ch 8 on extremes taking Judy's and John's points into account. The IPCC/NCA review is ported to an Appendix. I added a paragraph about LTP to the intro. I've incorporated the NE data. The bulk of the chapter is John's US temperature and precip data analysis with some additional material on wildfires, drought and TCs. For the US temperature extremes I moved the range figure to come just after the hot/cold extremes count because I think they both make a coherent point namely that the US becoming less extreme because heat events are rising more slowly than cold events are warming. There will still need to be an overall chapter summary but I'm going to move on to other chapters now. I'll put this in the Dropbox.

On Tue, May 6, 2025 at 12:12 PM John Christy <climateman60@gmail.com> wrote:

All

We can fill in without much trouble the change, or lack thereof, of “high impact” weather events (mainly wind and flooding like hurricanes, tornadoes etc) in the CONUS Extreme chapter. The temp and precip metrics are important because they are just long enough to essentially tell us Mother Nature has a mind of her own.

1. I'll look at Ross's version of 8 soon, but my hope was that Ross would translate the statistical remarks into the correct language(eg are their more precise words that chaotic, episodic, stochastic, etc).

2. We have analyses of the CONUS with more complete datasets than the NCA used (recall NCA analyses depended essentially on a small group at NCEI using datasets that (a) were not very consistent in time, (b) could promote alarm and (c) already easy for them to get to. Our datasets have literally hundreds of thousands of manually keyed-in observations for temporal consistency. In other words, this lets people know we can address these issues from soup to nuts - we're not armchair climate scientists ... we can reproduce what they did, but make the analysis more comprehensive to address the questions.

John C.

Sent from my iPhone

On May 6, 2025, at 4:14 AM, Ross McKittrick

<ross.mckittrick@gmail.com> wrote:

Just read your attribution chapter. I hadn't picked up on the gap between IPCC Ch 11 vs Ch 12 language but i see your point that rather than promoting one set of attribution findings we should explain that even within the same AR different authors assessed things differently. One option is to leave Ch 6 where it is but reverse the order of Ch 7 and 8 while retitling the latter as you suggest. That way, having established the extreme weather types for which there are no detectable trends it will more naturally follow that they won't be discussed in the attribution chapter.

On Tue, May 6, 2025 at 9:45 AM Judith Curry
<curry.judith@gmail.com> wrote:

Ok, but the summary table (12.12 from AR6) is inconsistent with conclusions in AR6 ch 11 (I point this out in section 6.4 of my attribution chapter).

In my mind, the main point is disagreement and ambiguity I would suggest chapter 8 going before chapter 6, retitling it as US Weather and Climate Extremes, and make it more of a data chapter, not an attribution chapter (I would put table 12.12 in the attribution chapter if you want to include the actual table)

On Tue, May 6, 2025 at 6:39 AM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I like john's material too which is why I included it and am working on the extended regional analyses. But on this topic people are heavily primed to believe that extreme weather of all kinds is getting worse due to climate change. The assertion shows up everywhere climate change is discussed including in academic papers. I think it is very valuable to show people that neither the IPCC nor the NCA support such this view. We should at least lead off with the summary table. The library of quotes can go to an appendix but I have found in my public speaking that they have considerable persuasive force for most people. We also need to address floods, droughts, hurricane landfalls, tornadoes etc. I don't see any reason to delete all that material.

On Tue, May 6, 2025 at 9:22 AM Judith Curry <curry.judith@gmail.com> wrote:

I actually liked John's chapter. I would have retitled it "US temperature and rainfall extremes"

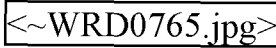
I think this is more relevant than a complete rehash of everything the last 3 IPCC reports have stated for every conceivable severe weather event.

John's version meshes very well with my version of chapter 6. Read especially section 6.4 of my chapter. I note a discrepancy between chapters 11 and 12 in terms of detecting and attributing extreme events. This is the main point in my opinion, there is ambiguity in all this. Lets focus on pointing out the problems/challenges, and topics that are particularly relevant for the US

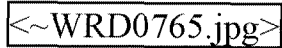
On Mon, May 5, 2025 at 7:47 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I have wrangled the extreme weather chapter into something I hope flows better and is more readable. I adopted Judy's editorial changes and then the new changes I made are in red. I added some new Figures showing results on PC and SE data and will add the NE chart when I get the data. I also made some labeling suggestions including for the 3 rainfall charts that are hard to understand. Section summaries and an overall summary are still needed.

Ross

--
A rectangular box containing the text "<~WRD0765.jpg>" in a monospaced font, indicating a redacted image.

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

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A rectangular box containing the text "<~WRD0765.jpg>" in a monospaced font, indicating a redacted image.

Judith Curry, President
CFAN - Climate Forecast Applications Network
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curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>



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Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: John Christy <climateman60@gmail.com>
Sent: Sunday, August 3, 2025 3:43 PM
To: Steve Koonin
Cc: Roy Spencer; Judith Curry; Ross McKittrick; Travis Fisher; Charles Park; Joshua Loucks; Seth Cohen; Audrey Barrios
Subject: Re: Hausfather Santer

Indeed - that's why models do fairly well at his elevations - simple radiative transfer of gasses with well-characterized responses.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On Aug 3, 2025, at 2:28 PM, Steven Koonin <steven.koonin@gmail.com> wrote:

Radiative changes in the stratosphere are a no brainer, I'd think- "just physics" that can be understood with simple 1d transfer. So you'd be surprised if you didn't find them.

Real action is lower down, with that messy convection and water vapor. Not so simple and so a real test of understanding.

Steven E. Koonin

On Aug 3, 2025, at 11:00, Roy Spencer <roywspencer@hotmail.com> wrote:

Again I will suggest NOT to accept the premise that just because more CO2 cools the stratosphere, even if there was perfect agreement with models, tropospheric feedbacks are so uncertain we don't have any confidence in tropospheric and surface warming. Two different issues. - Roy

Sent from my Verizon, Samsung Galaxy smartphone

----- Original message -----

From: John Christy <climateman60@gmail.com>

Date: 8/3/25 8:25 AM (GMT-06:00)

To: Judith Curry <curry.judith@gmail.com>

Cc: Ross McKittrick <ross.mckittrick@gmail.com>, Steve Koonin <steven.koonin@gmail.com>, Travis Fisher <travis.fisher@hq.doe.gov>, Roy Spencer <roywspencer@hotmail.com>, Charles Park <charles.park@hq.doe.gov>, Joshua Loucks <Joshua.Loucks@hq.doe.gov>, Seth Cohen <seth.cohen@hq.doe.gov>, Audrey Barrios <audrey.barrios@hq.doe.gov>
Subject: Re: Hausfather Santer

This from Santer

We may be able to address this in the DoE Reviewer responses since one of them mentioned this. I think Ben wants us to talk about the upper stratospheric signal which is well known (I have in a BAMS article several years ago). But that region is so thin, the 11-year solar cycle pops out. I don't see a controversy for the fingerprint pattern - it's the magnitude we are addressing, especially in the troposphere where moist thermodynamics plays havoc with models.

John C

https://www.linkedin.com/posts/ben-santer-29b3996_exceptional-stratospheric-contribution-to-activity-7357078563671474177-x8Fx?utm_source=social_share_send&utm_medium=member_desktop_web&rcm=ACoAAAB4cx4BQa9BI0CQEErETZ215X8rYPHTsIk

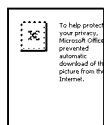
John C

Sent from my iPhone

On Aug 3, 2025, at 8:09 AM, Judith Curry
<curry.judith@gmail.com> wrote:

See this, is there anything relevant for our report here?

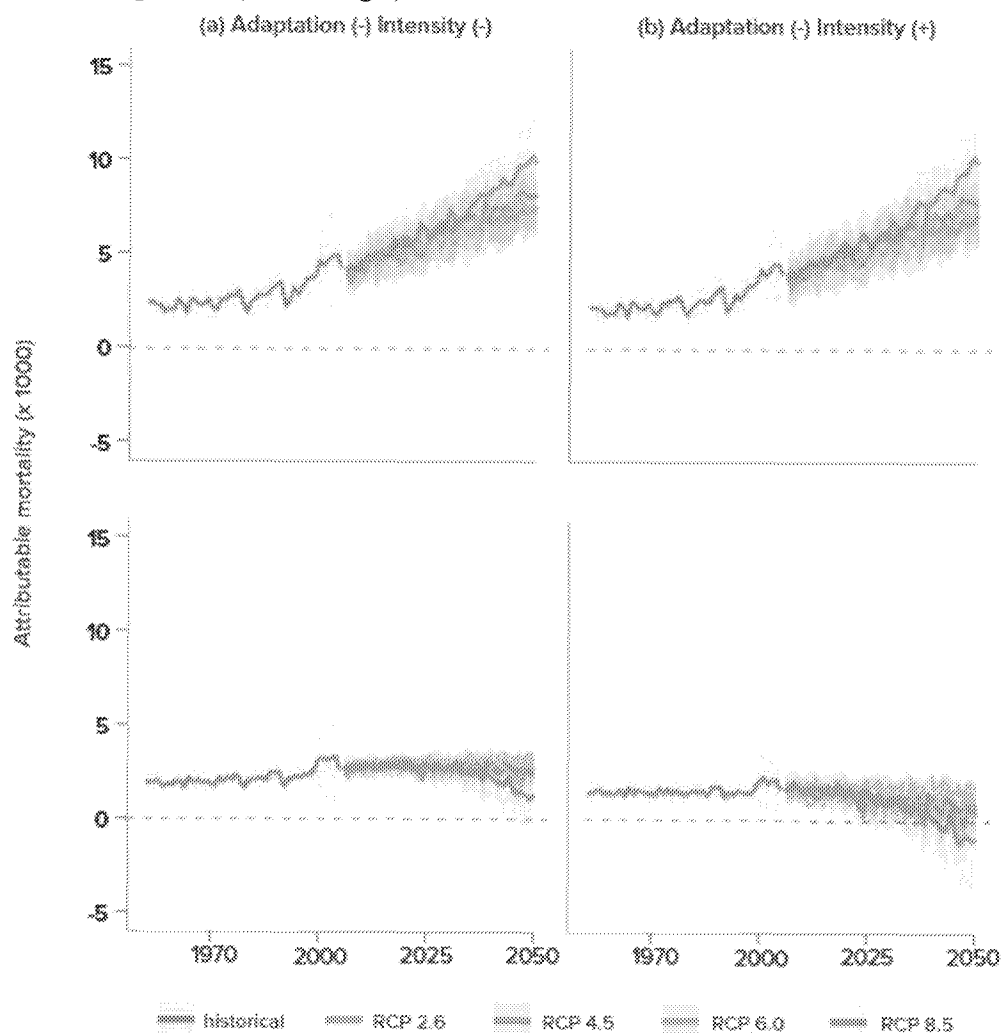
<https://www.theclimatebrink.com/p/how-the-doe-and-epa-used-and-misused>



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Ross McKittrick [ross.mckittrick@gmail.com]
Sent: 5/9/2025 8:13:44 PM
To: Judith Curry [curry.judith@gmail.com]
CC: Steven Koonin [steven.koonin@gmail.com]; John Christy [climateman60@gmail.com]; Roy W. Spencer [roywspencer@hotmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]
Subject: Re: heat-related mortality

I don't love that one either. I like this one from Wong, showing attributable mortality since 1960 and projections of future heatwave mortality with no controls for heatwave intensity or adaptation (top left) versus accounting for full adaptation (bottom right)

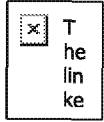


On Fri, May 9, 2025 at 2:48 PM Judith Curry <curry.judith@gmail.com> wrote:

All looks good. However, i suggest moving the figure, which only shows data from 1988-2000, i don't think this is useful to highlight with a figure

On Fri, May 9, 2025 at 9:59 AM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I added some additional information on declining heat-related mortality trends and the role of adaptation for future projections to the Ch on heat-related mortality. see attached



--

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Sunday, June 8, 2025 9:05 AM
To: Roy Spencer
Cc: John Christy; Judith Curry; Steve Koonin; Ross McKittrick; Josh Loucks; seth.cohen@hq.doe.gov
Subject: Re: How to respond to critics of our science...

I was trying to find a citation for this, and it looks like Pielke Jr. had a Substack article and X thread about it:
<https://open.substack.com/pub/rogerpielkejr/p/original-sin>

On Sun, Jun 8, 2025 at 8:27 AM Roy Spencer <roywspencer@hotmail.com> wrote:

Via Pielke Jr., nice that we have a blanket response already written to anyone who doesn't like our interpretation of the science (from NCA5 comments):



From: Ross McKittrick <ross.mckitrick@gmail.com>
Sent: Saturday, May 24, 2025 8:58 AM
To: Roy Spencer
Cc: John Christy; Steve Koonin; Judith Curry; Travis Fisher
Subject: Re: how to submit final edits?

The next step is to get the chapter reference lists done. Ch 4-7 remain. I'll be busy all day today and some of tomorrow so if anyone else can help please do. Entries in the list have to go into the right format (no numbering, year before article title, and first author last name first) and the list of citations in the chapter reconciled to references in the list. I plan to have that done by Sunday evening.

next we agree on edits in response to Chris' comments. Then everyone can take that draft and propose final edits. We could do that in a meeting on Tuesday.

On Sat, May 24, 2025 at 6:23 AM Roy Spencer <roywspencer@hotmail.com> wrote:

Should we submit our final edits/additions to Ross in emails, so we are all working from the same draft (recently circulated), like the Secretary did for his suggestions?

Given the few days left, I'd be OK with Ross agreeing/disagreeing with any suggested changes.

-Roy

From: John Christy <climateman60@gmail.com>
Sent: Thursday, August 14, 2025 1:15 PM
To: Judith Curry
Cc: Steve Koonin; Ross McKittrick; Roy Spencer
Subject: Re: Hurricane section

Judy

This reference list is quite revealing - the citations not mentioned in IPCC in particular due to new results. I wonder how many of our CWG references were not included in the thousands listed in WGI of IPCC?

I've been communicating with Dessler directly now. With me, they are asking questions about Chapter 6. They are grateful for our posting of the datasets and for the ancillary datasets I've sent that went into our analysis. So far, questions are pretty standard - the kinds Roy and I have dealt with all our lives (did you do areal-weighting, how to handle TOBs issues, etc.).

John C.

On Wed, Aug 13, 2025 at 4:55 PM Judith Curry <curry.judith@gmail.com> wrote:
Excellent that you are working with Dessler et al

Courtesy of Grok3

Cited in IPCC AR6 (WGI, primarily Chapter 11):

- Walsh et al. (2015)
- Kim and Ho (2018)
- Knaff et al. (2014)
- Kossin (2018)
- Lanzante (2019)
- Hall and Kossin (2019)
- Landsea and Franklin (2013)
- Bhatia et al. (2019)

Not Cited in IPCC AR6:

- Forbis et al. (2024): Post-cutoff
- Soule et al. (2012): Regional focus, not in bibliography
- Kellner et al. (2016): Regional focus, not in bibliography
- Aryal et al. (2018): Not in bibliography
- Guzman and Jiang (2021): Post-cutoff
- Tu et al. (2021): Post-cutoff
- Wang et al. (2025): Post-cutoff
- Fritz (2009): Thesis, not typically cited
- Kossin (2019): Reply, not primary research
- Garner (2023): Post-cutoff
- Balaguru et al. (2024): Post-cutoff
- Jewson and Lewis (2020): Not in bibliography

Notes

- The assessment is based on publication dates, relevance to AR6 WGI Chapter 11, and checks against available bibliographies. Some papers may not be cited due to regional focus, journal prominence, or overlap with more comprehensive studies.
- For papers published in 2021 or later, the AR6 cutoff (mid-2020) excludes them automatically.
- If you need further details or want me to check specific AR6 chapters beyond WGI, let me know!

On Wed, Aug 13, 2025 at 2:18 PM John Christy <climateman60@gmail.com> wrote:
Excellent Judy. Were many of the newly included studies cited in the IPCC?

I'm having conversations with the Dessler group ... being completely helpful with data and methods used in Chapter 6.

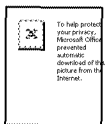
John C.

On Wed, Aug 13, 2025 at 3:13 PM Judith Curry <curry.judith@gmail.com> wrote:
See attached revisions to the hurricane section. I think this strengthens the text without diluting our main points. I look forward to your feedback/comments.

--



Judith Curry, President
CFAN - Climate Forecast Applications Network
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curry.judith@cfanclimate.com | +1.404.803.2012
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From: Judith Curry [curry.judith@gmail.com]
Sent: 5/14/2025 2:41:07 PM
To: Ross McKittrick [ross.mckittrick@gmail.com]; Roy Spencer [roywspencer@hotmail.com]; John Christy [climatemanager60@gmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]; Steven Koonin [steven.koonin@googlemail.com]
Subject: Re: Hurricanes
Attachments: ch 8 wildfires.docx

Attached is some additional text on wildfires for Ch 8

On Tue, May 13, 2025 at 7:09 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:
I put it and John's revised Figure and the shortened 8.2 into the new version in the DB.

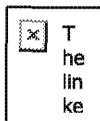
On Tue, May 13, 2025 at 11:01 AM Judith Curry <curry.judith@gmail.com> wrote:
My take on section 8.3 Hurricanes (avoids ACE and PDI)

--



Judith Curry, President
CFAN - Climate Forecast Applications Network
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Forest fires have always been a part of nature, and they can certainly create conditions that are inhospitable in the short term for all life including humans. Science has confirmed the overall benefit and necessity of the occurrence of forest fires. While recent high-profile fires and seasons serve as a reminder of the potential destructive impact, the highest profile forest fire remains the 1910 Big Blowup fire which destroyed over three million acres including the elimination of entire towns like Taft, MT.ⁱ The 1910 fire reshaped the U.S. Forest Service,ⁱⁱ leading to a focus on fire suppression with a primary goal to defeat all forest fires.ⁱⁱⁱ This led to the 10 am rule in 1935 that meant all fires spotted on any day had to be controlled by the following day at 10 am.^{iv}

While defeating fire is certainly a noble goal, questions began to arise as to whether this behavior “followed the science.”^v Over time the U.S. Forest Service has begun to rethink its behavior, recognizing that new approaches such as prescribed burns, fuel elimination and controlled wildfires are more appropriate.^{vi} Recent research is validating this approach and recognizing that more frequent smaller fires in forests likely result in the most healthy forests, water ecosystems and biodiversity.^{vii}

ⁱ Charles Apple, “1910 Fire - the Big Burn across Montana and Idaho,” Spokesman.com (The Spokesman-Review, January 21, 2020), <https://www.spokesman.com/stories/2020/jan/19/1910-fire-big-burn-across-montana-and-idaho/>.

ⁱⁱ “Blazing Battles: The 1910 Fire and Its Legacy,” National Forest Foundation, accessed September 28, 2022, <https://www.nationalforests.org/our-forests/your-national-forests-magazine/blazing-battles-the-1910-fire-and-its-legacy>.

ⁱⁱⁱ “The 1910 Fires,” Forest History Society, accessed September 28, 2022, <https://foresthistory.org/research-explore/us-forest-service-history/policy-and-law/fire-u-s-forest-service/famous-fires/the-1910-fires/>.

^{iv} “Blazing Battles: The 1910 Fire and Its Legacy.”

^v “Managing Fire,” US Forest Service, September 28, 2022, <https://www.fs.usda.gov/science-technology/fire>.

^{vi} Lauren Sommer, “Let It Burn: The Forest Service Wants to Stop Putting out Some Fires,” KQED, November 7, 2016, <https://www.kqed.org/science/1134217/let-it-burn-the-forest-service-wants-to-stop-putting-out-some-fires>.

^{vii} Scott L. Stephens et al., “Fire, Water, and Biodiversity in the Sierra Nevada: A Possible Triple Win,” *Environmental Research Communications* 3, no. 8 (August 6, 2021): p. 081004, <https://doi.org/10.1088/2515-7620/ac17e2>.

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Sent: Friday, April 18, 2025 11:49 AM
To: Roy Spencer
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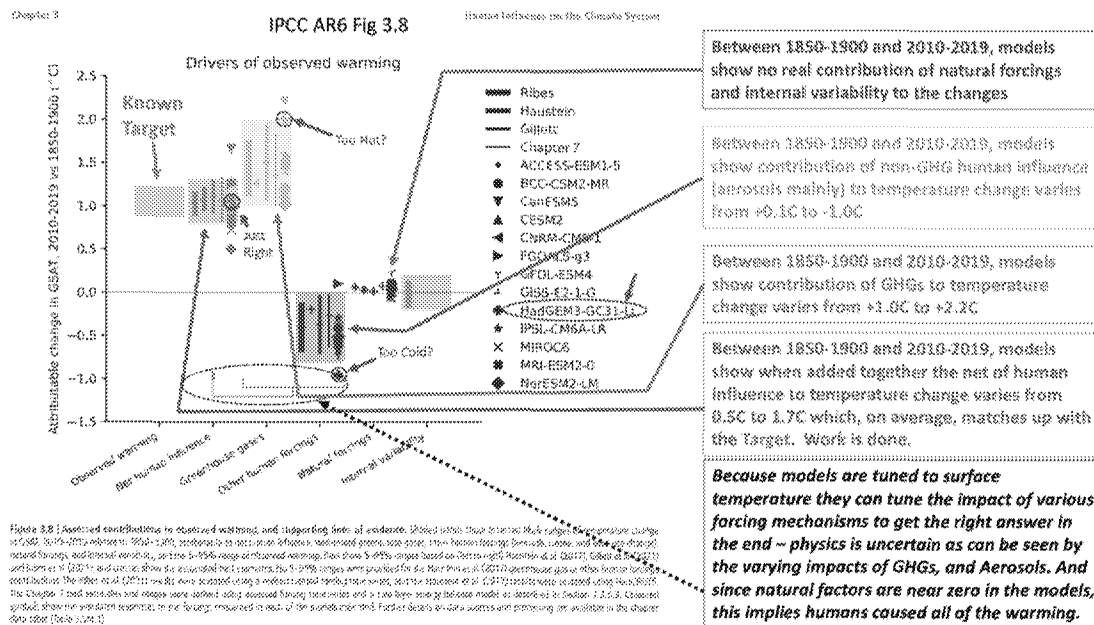
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To: Ross McKittrick <ross.mckittrick@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>

Cc: Steven Koonin <steven.koonin@gmail.com>; John Christy <climateman60@gmail.com>

Subject: Section 1.4.3 attached

Ross:

I think we should combine sections 1.4.3 and 1.4.4 (attached) which I now call "The carbon cycle, emissions scenarios, and global greening".

I found that all of these need to be discussed together. Feel free to reword the section title.

-Roy

From: Roy Spencer <roywspencer@hotmail.com>

Sent: Thursday, April 17, 2025 6:17 AM

To: Ross McKittrick <ross.mckittrick@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>
Cc: Steven Koonin <steven.koonin@gmail.com>; John Christy <climateman60@gmail.com>
Subject: Section 1.4.2 Can climate models reproduce the recent past?

Attached. This is the minimum I think needs to be in this section. Of course, more could be added, but I think we need to stick to our strongest arguments, given the limited time available.

-Roy

From: Roy Spencer <roywspencer@hotmail.com>
Sent: Wednesday, April 16, 2025 7:16 AM
To: Ross McKittrick <ross.mckittrick@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>
Cc: Steven Koonin <steven.koonin@gmail.com>; John Christy <climateman60@gmail.com>
Subject: Some Spencer inputs

I took it upon myself to write a preamble in **Section 1.3 Drivers of climate change** (attached), which seemed necessary to introduce some basic concepts.

Also attached are my initial submissions for **1.3.2** and **1.3.3**.

NO references added yet.

One of the things I believe we need to watch out for is *neglecting to come to conclusions along the way*... There is a tendency to get mired in the technical details without getting around to saying what each section might mean in eventual policy decisions related to the Endangerment Finding. In my experience, it is not possible to dumb-down this stuff too much. I suggest some sort of "Summary Boxes" with 1-2 simplified statements highlighting a main conclusion of each section that would have policy relevance.

-Roy

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Monday, April 14, 2025 1:37 PM
To: Travis Fisher <travis.scott.fisher@gmail.com>
Cc: Steven Koonin <steven.koonin@gmail.com>; John Christy <climateman60@gmail.com>;
roywspencer@hotmail.com <roywspencer@hotmail.com>
Subject: Re: Kickoff

Hi Travis
We developed the outline a bit further and assigned sections out yesterday. We'll keep you cc'd going forward.

Here is a Dropbox link that contains the current outline (also attached) which indicates who is working on each section

https://www.dropbox.com/sc/1fo/wahx6lpwzu33m5vyrr8x/ANTU1qAQJ-zXCFzP_gsJcOs?rlkey=llz3qj9v46e1t5f4ywwxq7p8c&dl=0
The link should give you all editing privileges.

I put folders in there for each of us. If the use of that Dropbox (which is on my own account) is acceptable for this project then we can share our work using it. Otherwise once we have an official Dropbox created we can transfer the material over to it.

Do you think it would be helpful to have a section specifically addressing the question of whether CO2 is a pollutant like CO, NOx, SOx, PM, etc.? If you want to add topics or suggest changes please do, the earlier the better as we begin filling out the contents.

Cheers,

Ross

On Mon, Apr 14, 2025 at 2:12 PM Travis Fisher <travis.scott.fisher@gmail.com> wrote:

This is an excellent start! Can we move forward by iterating with this document for now? Please feel free to add whatever material you like, and I can collate if there are any simultaneous changes. I will leave the substance to you all because I view my role as a facilitator rather than a contributor, but please let me know how I can be most helpful.

Steve is correct that this document should be clear and understandable for non-experts. My understanding is that it should also be sufficiently technical and comprehensive to inform policymakers on all relevant aspects of the science.

One area I can help with might be targeting your work for the very brief window we have open at the moment. I am including a few lines verbatim below from key documents to highlight the areas of inquiry that are most relevant to the policymaking process. Of course, you all should make your own judgments about what to include versus what to leave out.

Here is a key section of the Clean Air Act, 202(a)(1): "The Administrator shall by regulation prescribe (and from time to time revise) in accordance with the provisions of this section, standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines, which in his judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare. Such standards shall be applicable to such vehicles and engines for their useful life (as determined under subsection (d), relating to useful life of vehicles for purposes of certification), whether such vehicles and engines are designed as complete systems or incorporate devices to prevent or control such pollution."

Section 202 can be found [here](#).

Here is another key section of the Clean Air Act, section 302(g): "The term 'air pollutant' means any air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive (including source material, special nuclear material, and byproduct material) substance or matter which is emitted into or otherwise enters the ambient air. Such term includes any precursors to the formation of any air pollutant, to the extent the Administrator has identified such precursor or precursors for the particular purpose for which the term 'air pollutant' is used."

A threshold question raised in Justice Scalia's dissent in *Mass v. EPA* (which can be found [here](#)) is whether CO2 falls under the definition of an "air pollutant" under the Clean Air Act. The majority in *Mass v. EPA* found that *any* compound emitted into the ambient air fits the definition of "air pollutant," leading to a colorful footnote in the Scalia dissent ("It follows that everything airborne, from Frisbees to flatulence, qualifies as an 'air pollutant.' This reading of the statute defies common sense."). A scientific interpretation of this definition could be very helpful.

The next section in the statute is 302(h), which defines effects on welfare: "All language referring to effects on welfare includes, but is not limited to, effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being, whether

caused by transformation, conversion, or combination with other air pollutants." Positive impacts, including fertilization effects and beneficial warming, seem to be within scope here.

Section 302 can be found [here](#).

As you all develop the draft, I encourage you to include as many citations to published materials as possible (links would work fine as placeholders). I have found this works better under a tight timeline than going back and looking for sources later. Please also feel free to task me with any research help you might need.

Best,
Travis

On Fri, Apr 11, 2025 at 8:10 PM Steven Koonin <steven.koonin@gmail.com> wrote:
I assume we're writing for non-experts. If so, some educating beyond the root questions is in order (it always helps if people feel smarter after reading).

So I've taken Ross' material, added some broader context, and cast it into the forcing/response/impact syllogism that most non-experts seem to get. The result is attached.

I think we can deal with the differences relative to 2009 in an appendix.

SEK

From: John Christy <climateman60@gmail.com>
Sent: Friday, April 11, 2025 6:34 PM
To: Ross McKittrick <ross.mckittrick@gmail.com>
Cc: Travis Fisher <travis.scott.fisher@gmail.com>; steven.koonin@gmail.com; roywspencer@hotmail.com
Subject: Re: Kickoff

Excellent list Ross. Wildfires are a significant topic to be addressed.

John C.

Sent from my iPhone

On Apr 11, 2025, at 4:05 PM, Ross McKittrick <ross.mckittrick@gmail.com> wrote:

The attached represents my summary of the most questions needing to be answered, which I think this group is capable of answering in the next couple of weeks. Probably lots of material already in hand.

On Fri, Apr 11, 2025 at 4:24 PM Travis Fisher <travis.scott.fisher@gmail.com> wrote:

Gentlemen,

I can't thank you enough for taking this on under such a tight timeline. Let's use this thread to exchange information, links, etc., and as we move forward, I'll see about a document-sharing platform and a shared document to work on simultaneously.

Best,

Travis

<DE.memo.outline.Apr.11.[RM].docx>

Empirical methods [RM]

Equilibrium Climate Sensitivity (ECS) is defined as the expected amount of warming averaged over the Earth's surface in response to a doubling of CO₂, after all climate systems have had time to adjust. Some systems, like temperatures in the troposphere, adjust very rapidly. Others may take decades or even centuries, such as the deep ocean and the cryosphere. A related metric which is sometimes more helpful on shorter time scales is the Transient Climate Response (TCR) defined as the amount of warming after 70 years in which atmospheric CO₂ goes up by one percent annually.

In large-scale General Circulation Models (aka climate models) ECS is not imposed as a direct parameter, instead it emerges from the behaviour of the underlying components of the model. These, however, are under the control of the modeler, so ultimately a model's ECS can be said to be built into it. Direct warming from CO₂ doubling is only about 1°C; the rest (to the extent more happens) arises due to climate feedbacks which are inherently more difficult to predict and model.

In 1979 the Charney (1979) Report for the US National Academy of Sciences proposed that the most likely value for ECS was 3.0°C plus or minus 1.5°C. Hence the best estimate was a likely tripling of the CO₂ effect through feedbacks. With only minor variations this range was adopted and reaffirmed by the IPCC until the most recent AR6. The range has been obtained primarily by examining the behaviour of climate models, but since key components of models are under the control of modelers this is not determinative of the actual climate's sensitivity. For example, Mauritsen and Roeckner (2020) confess regarding their Max Planck Institute model, "We have documented how we tuned the MPI-ESM1.2 global climate model to match the instrumental record of warming; an endeavor which has clearly been successful. Due to the historical order of events, the choice was to do this practically by *targeting an ECS of about 3 K using cloud feedbacks*, [emphasis added] as opposed to tuning the aerosol forcing." In other words, without appealing to fundamental physics the modelers chose an ECS of 3 K then tuned the cloud feedbacks to match their intended result.

A significant amount of effort has gone into estimating ECS empirically. There are several challenges to this work.

- First, it requires good data but observations of some key climatic systems, especially the oceans, are available in only very limited amounts.
- Second, identifying the effect of CO₂ requires simultaneously identifying the effect of aerosols. Climate models exhibit warming in response to GHGs but cooling in response to aerosols (Schwartz et al. 2007). Observed 20th century warming can be shown to be consistent either with low ECS and low aerosol cooling or high ECS and high aerosol cooling. Since fossil fuel use adds both GHGs and aerosols to the atmosphere, both effects need to be estimated to isolate the warming effect of CO₂. Over time the IPCC's estimate of the cooling effect of aerosols has declined (Lewis 2022).
- Third, the simple empirical model typically used for the estimation, called an Energy Balance Model, requires estimating a feedback parameter which appears in the denominator of the equation for ECS. A small amount of uncertainty about the number in the denominator of a fraction can lead to very large uncertainties in the magnitude of the fraction itself. Roe and Baker (2007) pointed out that uncertainties in climate feedbacks are "highly amplified" in the resulting ECS.

Since 2012 many studies have appeared in the literature tackling these various uncertainties. A recurring theme is that ECS estimates based on historical data turn out to be smaller than ECS estimates inferred from climate models (Sherwood and Forest 2024). An early estimate (Stern and Kaufmann 2000) was 1.6°C, though this predated development of the Energy Balance Model method. Figure 1.6.1 shows the point or best estimates from 17 subsequent studies all appearing in the peer-reviewed literature after the TSD. The Charney range is shown for contrast. The average ECS estimate in the post-2012 sample is 1.8°C. The highest estimate, from Sherwood et al. 2020, is shown in red: it is the one that was used by the IPCC for the AR6 (Forster et al. 2021). The one adjacent to it, Lewis (2022), shows the result of, among other things, using the same method but applying more updated aerosol forcing data in the AR6 as well as some other recent updates to the source data. These updates dropped the ECS best estimate back down closer to the usual empirical range. The IPCC, following Sherwood et al. (2020) had estimated only a 5 percent probability that ECS was below 2.3°C was only 5 percent, whereas Lewis (2022) estimated it was over 50 percent.

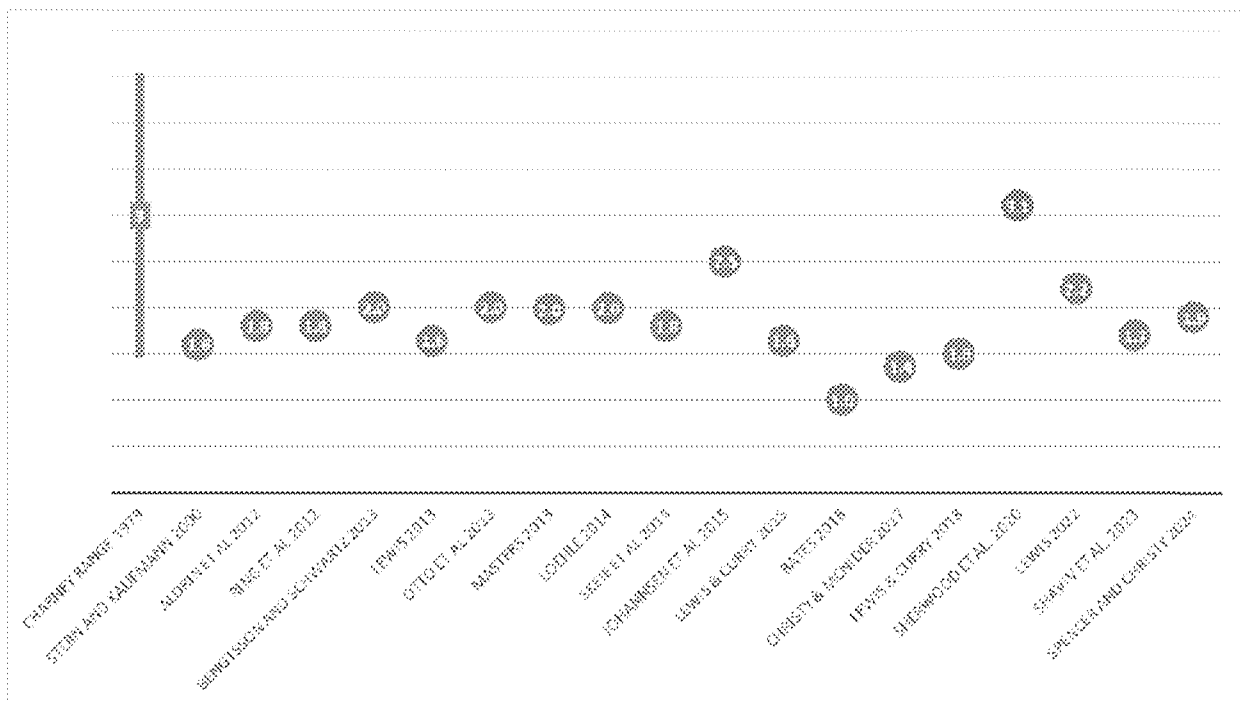


Figure 1.6.1: Empirical best estimates of ECS

A recent argument, one which the IPCC emphasized, that empirical ECS estimates might understate the future warming response to GHGs is based on a so-called “pattern effect” (Forster et al 2021). The tropical Pacific is believed to be highly influential on the overall efficiency with which the Earth’s climate radiates heat to space, but heat in some parts is more efficiently removed than from others. If in a warming climate there is a weakening of the west-to-east temperature gradient in the tropical Pacific the result would be a concentration of warming in a region where heat is less efficiently removed, raising the ECS of the Earth’s climate system. Most climate models simulate that rising GHGs will weaken the east-west temperature gradient, which led the IPCC in the AR6 to conclude that empirical ECS estimates understated what would be the *future* observed ECS value.

However Seager et al. (2019) pointed out that, contrary to models, the east-west temperature gradient has been strengthening rather than weakening over time. They further argued that the mechanism predicting otherwise in climate models was based on a faulty characterization of oceanic dynamics and there is no reason to expect the gradient to weaken. A similar argument was recently made by Lee et al. (2024), who concluded that “the trajectory of the observed trend reflects the response to increasing GHG loading in the atmosphere”, in other words GHG warming should lead to a future strengthening rather than a weakening of the temperature gradient. This implies, if anything, that future ECS in a warming climate will be lower than at present.

In summary, while the ECS range in climate models is very wide, historically climate models have embedded processes and assumptions that about secondary feedbacks that approximately triple the warming from CO₂. Empirical estimates since the TSD however imply the climate is much less sensitive to CO₂ than this, with the estimates centered at or below 2°C. As discussed in Section 1.4.2 this is supported by studies which show climate models on average estimate too much warming at the surface and in the troposphere compared to observations over the past 50 years, and low-ECS models do better than high-ECS ones. Also this aligns with evidence from consistent fingerprinting (Section 1.5.1) that model responses to GHGs need to be scaled down quite a bit to align with observed trends. As will be discussed in Section 3.6, ECS values in the range of 2.0°C imply very low Social Cost of Carbon values.

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- Hall, Alex and Syukuro Manabe (1997) The Role of Water Vapor Feedback in Unperturbed Climate Variability and Global Warming. *Journal of Climate* August 1999 Vol 12 pp. 2327—2346.

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Friday, April 18, 2025 4:59 PM
To: John Christy
Cc: Roy Spencer; Travis Fisher; Steven Koonin
Subject: Re: I'll need help: 10 sections to go

Thanks John. The quote from Mauritsen and Roeckner is a great addition.
I find the figure hard to follow, whereas the quote makes the point very clearly, in their own words.

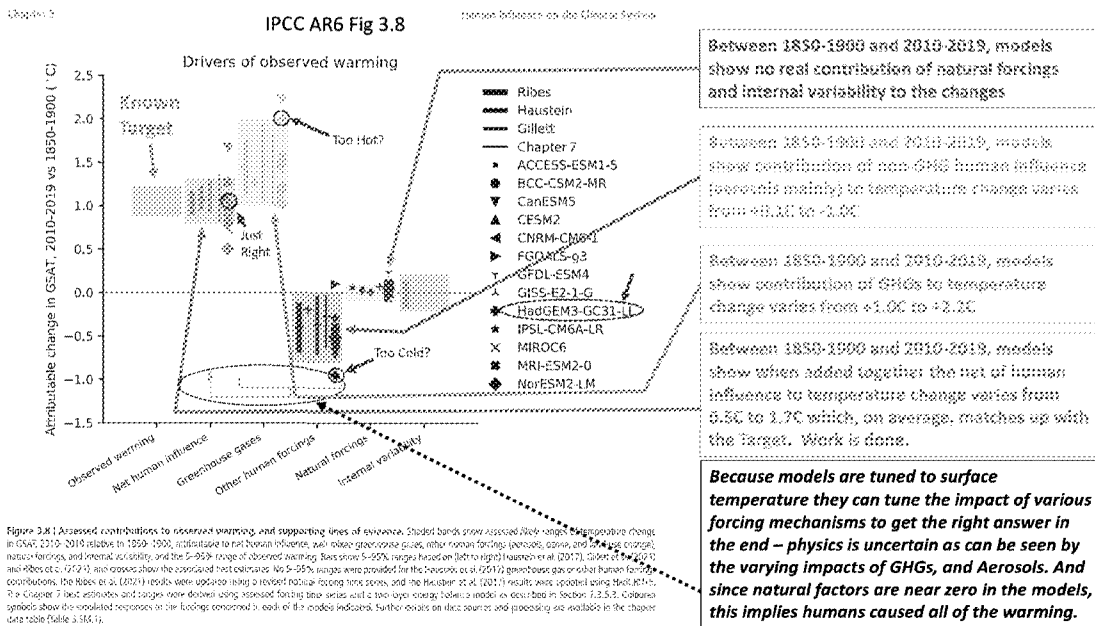
On Fri, Apr 18, 2025 at 4:55 PM John Christy <climateman60@gmail.com> wrote:
Ross

I've never been successful with dropbox and my record is still intact.

Attached is 1.6.2 to which I added a paragraph.

Also attached is a chart I annotated from AR6. I think this story demonstrates modelers are just playing with tuning parameters. Is there some way to use this information here (not necessarily in this format)?

John C.



On Fri, Apr 18, 2025 at 3:32 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I've uploaded a new version of Section 2.2 to your folder. It includes the earlier material quoting all the relevant IPCC and NCA17 stuff and adds some external source information I found. Still needs a brief summary. Others may have more to add.

On Fri, Apr 18, 2025 at 3:05 PM Roy Spencer <roywspencer@hotmail.com> wrote:

Ross:

Let me look early in the morning to see which ones I feel like I can knock out the fastest. Our "guidance" has been to start from "scratch", while relying on preexisting materials where it helps. I think I know why we've been told this, but it's not my place to say.

- Roy

Sent from my Verizon, Samsung Galaxy smartphone

----- Original message -----

From: Ross McKittrick <ross.mckittrick@gmail.com>

Date: 4/18/25 10:49 AM (GMT-06:00)

To: Roy Spencer <roywspencer@hotmail.com>

Cc: Travis Fisher <travis.scott.fisher@gmail.com>, Steven Koonin <steven.koonin@gmail.com>, John Christy <climateman60@gmail.com>

Subject: Re: I'll need help: 10 sections to go

Sorry Roy, I didn't mean to swamp you, I figured those were sections you already had in the can from previous work. Looking through my own folders I have some material I forgot I had written which I can repurpose. Can you send a list of the sections you are able to do, and the ones you would like to hand off for the time being?

Also to Travis' point we should look to having Judy help some of the sections. Travis, she can be reached via curry.judith@gmail.com

Ross

On Fri, Apr 18, 2025 at 7:40 AM Roy Spencer <roywspencer@hotmail.com> wrote:

All:

I don't see how I'm going to do the 10 more sections assigned to me (1.6.1 onward) in the time remaining. Feel free to jump in.

-Roy

From: Roy Spencer <roywspencer@hotmail.com>

Sent: Friday, April 18, 2025 6:34 AM

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Cc: Steven Koonin <steven.koonin@gmail.com>; John Christy <climateman60@gmail.com>

Subject: Section 1.4.3 attached

Ross:

I think we should combine sections 1.4.3 and 1.4.4 (attached) which I now call "The carbon cycle, emissions scenarios, and global greening".

I found that all of these need to be discussed together. Feel free to reword the section title.

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Cc: Steven Koonin <steven.koonin@gmail.com>; John Christy <climateman60@gmail.com>

Subject: Section 1.4.2 Can climate models reproduce the recent past?

Attached. This is the minimum I think needs to be in this section. Of course, more could be added, but I think we need to stick to our strongest arguments, given the limited time available.

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Cc: Steven Koonin <steven.koonin@gmail.com>; John Christy <climateman60@gmail.com>

Subject: Some Spencer inputs

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Also attached are my initial submissions for **1.3.2** and **1.3.3**.

NO references added yet.

One of the things I believe we need to watch out for is *neglecting to come to conclusions along the way*... There is a tendency to get mired in the technical details without getting around to saying what each section might mean in eventual policy decisions related to the Endangerment Finding. In my experience, it is not possible to dumb-down this stuff too much. I suggest some sort of "Summary Boxes" with 1-2 simplified statements highlighting a main conclusion of each section that would have policy relevance.

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Subject: Re: Kickoff

Hi Travis

We developed the outline a bit further and assigned sections out yesterday. We'll keep you cc'd going forward.

Here is a Dropbox link that contains the current outline (also attached) which indicates who is working on each section

https://www.dropbox.com/scl/fo/wahx6lpwzu33m5vyri8x/ANTU1qAQJ-zXCFzP_gsJcOs?rlkey=l1z3qj9v46e1t5f4ywwxq7p8c&dl=0

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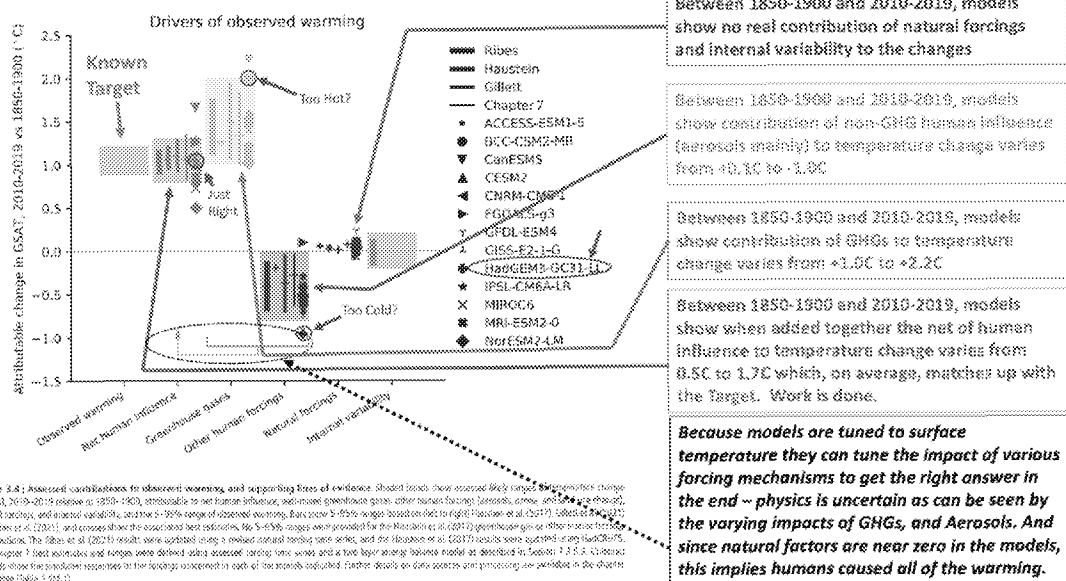
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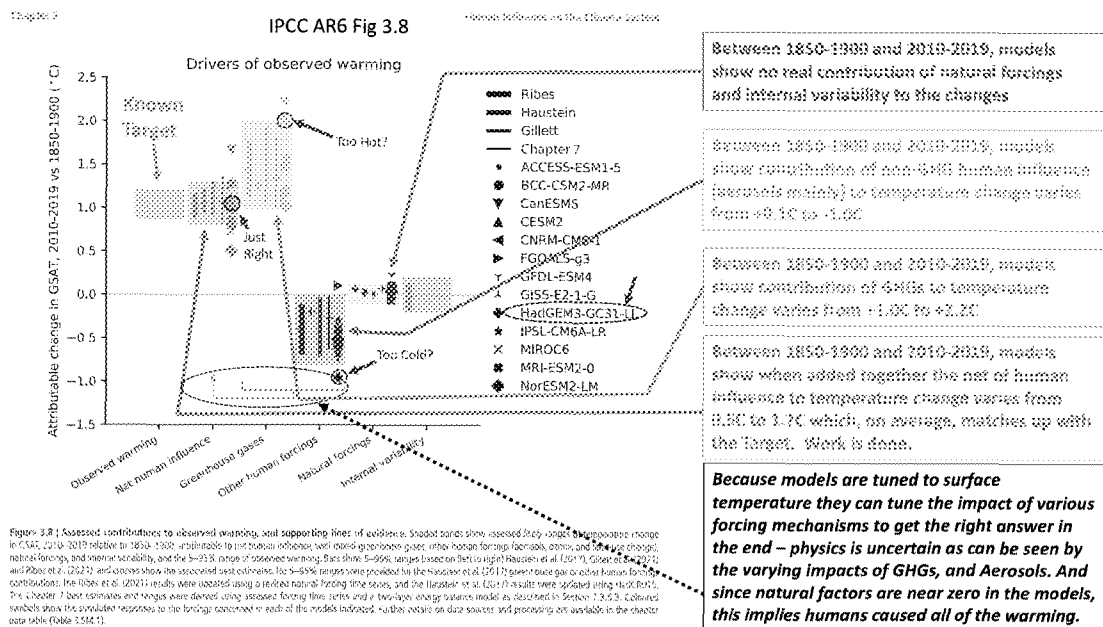
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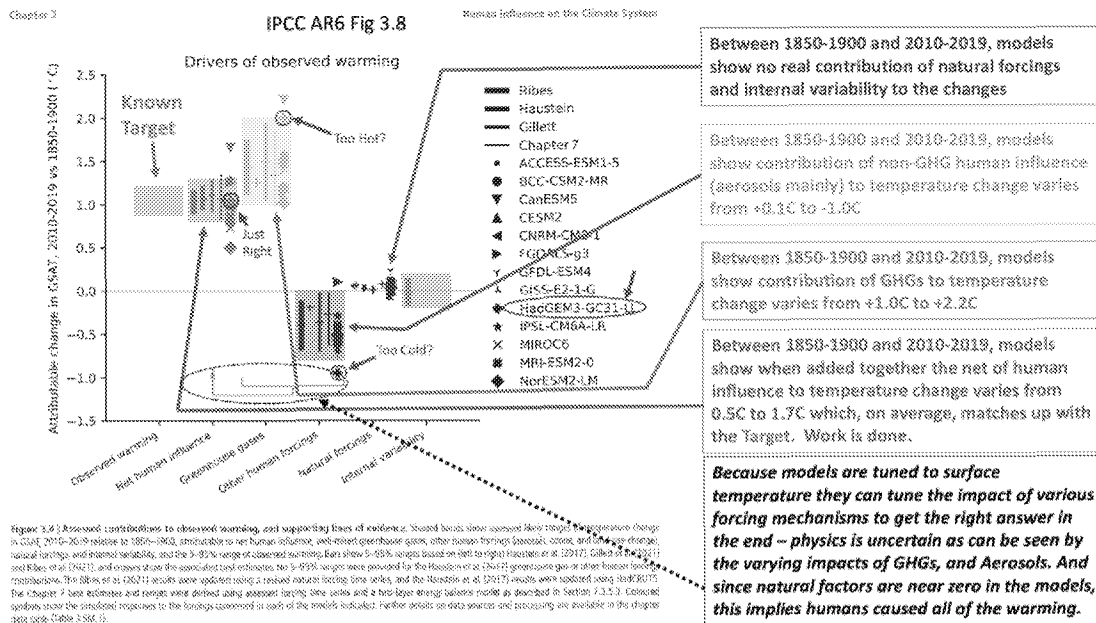
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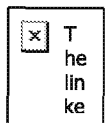
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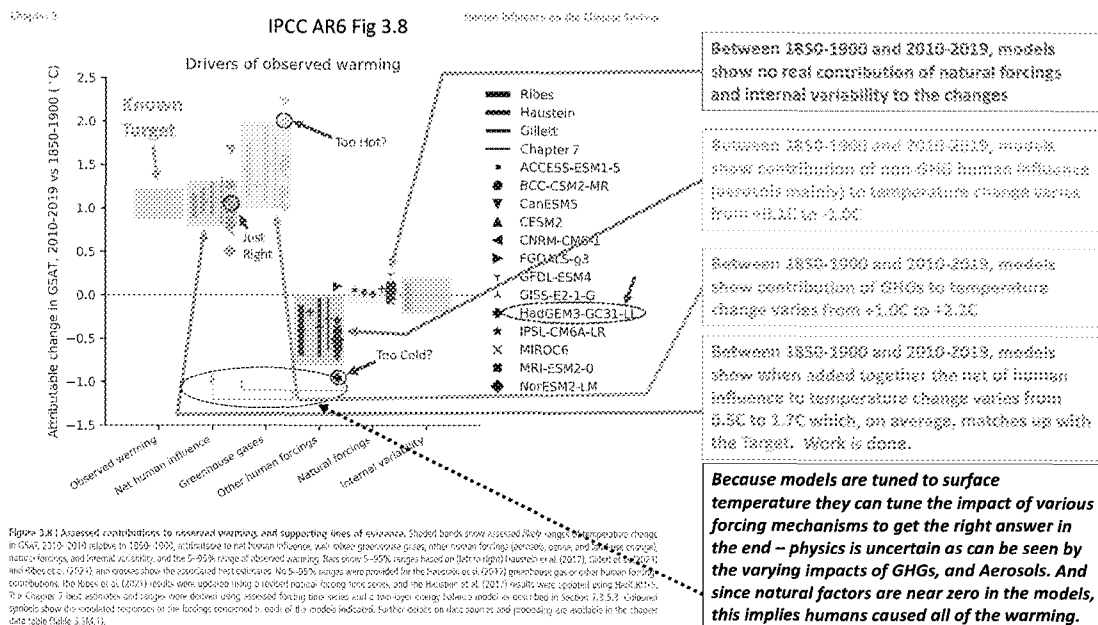
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Sent: Friday, April 11, 2025 6:34 PM

To: Ross McKittrick <ross.mckittrick@gmail.com>

Cc: Travis Fisher <travis.scott.fisher@gmail.com>; steven.koonin@gmail.com; roywspencer@hotmail.com

Subject: Re: Kickoff

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Judith Curry, President
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Steve is correct that this document should be clear and understandable for non-experts. My understanding is that it should also be sufficiently technical and comprehensive to inform policymakers on all relevant aspects of the science.

One area I can help with might be targeting your work for the very brief window we have open at the moment. I am including a few lines verbatim below from key documents to highlight the areas of inquiry

that are most relevant to the policymaking process. Of course, you all should make your own judgments about what to include versus what to leave out.

Here is a key section of the Clean Air Act, 202(a)(1): "The Administrator shall by regulation prescribe (and from time to time revise) in accordance with the provisions of this section, standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines, which in his judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare. Such standards shall be applicable to such vehicles and engines for their useful life (as determined under subsection (d), relating to useful life of vehicles for purposes of certification), whether such vehicles and engines are designed as complete systems or incorporate devices to prevent or control such pollution."

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A threshold question raised in Justice Scalia's dissent in *Mass v. EPA* (which can be found [here](#)) is whether CO₂ falls under the definition of an "air pollutant" under the Clean Air Act. The majority in *Mass v. EPA* found that *any* compound emitted into the ambient air fits the definition of "air pollutant," leading to a colorful footnote in the Scalia dissent ("It follows that everything airborne, from Frisbees to flatulence, qualifies as an 'air pollutant.' This reading of the statute defies common sense."). A scientific interpretation of this definition could be very helpful.

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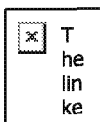
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To: Judith Curry
Cc: Travis Fisher; Ross McKittrick; Roy Spencer; Steven Koonin
Subject: Re: I'll need help: 10 sections to go

Judy

Sounds like you're jumping in with both feet. I'm not aware of our role on the legal aspect of "air pollutant", but I think we'd like to see what you have. Travis is our guide, but we're really all throwing what we have together now to build a good draft by the end of the month. Steve will be back from India tomorrow and Ross is keeping track of the Master document.

I'm still trying to figure out Dropbox, so for now I'm sending pieces to Ross.

Glad you're aboard.

John C.

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<Fig_AR6_3.8_Apr18[JC].png>

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automatic download of this picture from the Internet.

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Thanks so much, Judy!

Great questions. I don't think anyone has taken on the "air pollutant" issue. Please feel free to tackle it if you like!

Regarding the regulation in question, I've been told this summary of the science will be published as a technical support document relevant to a new proposed rule on tailpipe emissions standards for motor vehicles. I don't know whether that means all motor vehicles or just light- and medium-duty vehicles. It might be helpful to differentiate GHG emissions from the different classes to give the EPA flexibility in that regard.

The previous administration combined the rules for GHGs and criteria pollutants into a "multi-pollutant" rule, and I don't have any information on how this administration will package the different emissions standards. The exact charge for you all is to provide an update on the science relevant to the EPA's endangerment determination with respect to GHGs. As I understand the assignment, the scope is only GHGs, not criteria pollutants.

Keep the questions coming! I can run them up the chain if I don't know the answers, and I am happy to relay any questions you all have to the relevant folks at DOE or other agencies.

For your awareness, I was asked to share the table of contents with the EPA team this evening, which I did (the April 18 version), with the understanding that it is a one-way street (me informing them of your work so they know what's coming, not them sending feedback or micro-managing it). As I assured Steve in the early stages of this work, scientific integrity is paramount, and I will do everything in my power to preserve every word of the document as you all write it. In fact, the EPA team asked that the document be DOE-branded, meaning our true audience is the Secretary of Energy, and he emphasized to me that he wants nothing but science. In other words, the only compromise you have to make in how this is written is among yourselves, not between you all and policymakers, lawyers, or economists.

Thanks again for lending your expertise to this effort, all of you.

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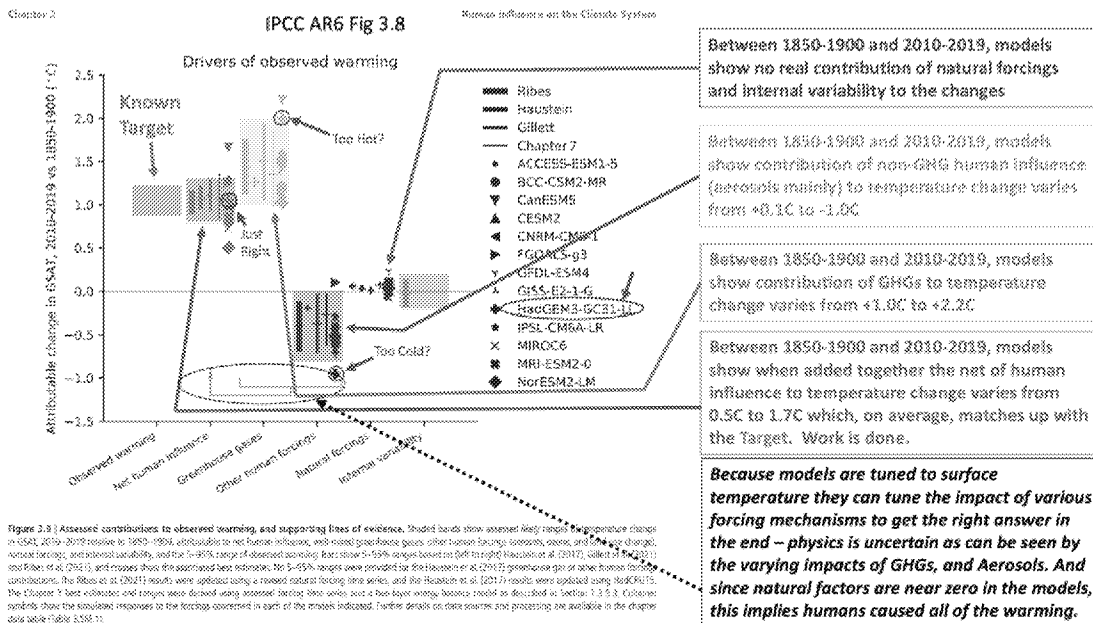
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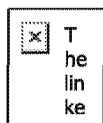
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Keep the questions coming! I can run them up the chain if I don't know the answers, and I am happy to relay any questions you all have to the relevant folks at DOE or other agencies.

For your awareness, I was asked to share the table of contents with the EPA team this evening, which I did (the April 18 version), with the understanding that it is a one-way street (me informing them of your work so they know what's coming, not them sending feedback or micro-managing it). As I assured Steve in the early stages of this work, scientific integrity is paramount, and I will do everything in my power to preserve every word of the document as you all write it. In fact, the EPA team asked that the document be DOE-branded, meaning our true audience is the Secretary of Energy, and he emphasized to me that he wants nothing but science. In other words, the only compromise you have to make in how this is written is among yourselves, not between you all and policymakers, lawyers, or economists.

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On Fri, Apr 18, 2025 at 8:46 PM Judith Curry <curry.judith@gmail.com> wrote:

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Roy, let me know if there are sections you can't complete, i may have some text that is already written

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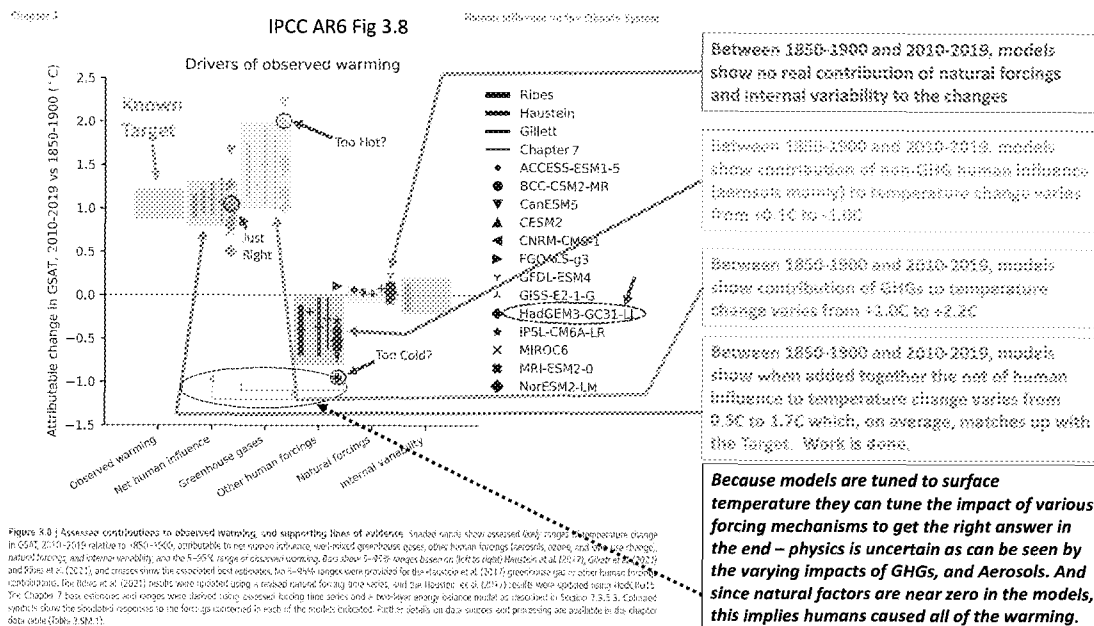
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For your awareness, I was asked to share the table of contents with the EPA team this evening, which I did (the April 18 version), with the understanding that it is a one-way street (me informing them of your work so they know what's coming, not them sending feedback or micro-managing it). As I assured Steve in the early stages of this work, scientific integrity is paramount, and I will do everything in my power to preserve every word of the document as you all write it. In fact, the EPA team asked that the document be DOE-branded, meaning our true audience is the Secretary of Energy, and he emphasized to me that he wants nothing but

science. In other words, the only compromise you have to make in how this is written is among yourselves, not between you all and policymakers, lawyers, or economists.

Thanks again for lending your expertise to this effort, all of you.

Best,
Travis

On Fri, Apr 18, 2025 at 8:46 PM Judith Curry <curry.judith@gmail.com> wrote:

I have a lot of material already written that should be relevant. I have a draft of the sea level rise section completed, am sending this to my assistant to format, will upload monday.

Roy, let me know if there are sections you can't complete, i may have some text that is already written

On Fri, Apr 18, 2025 at 3:06 PM Travis Fisher <travis.scott.fisher@gmail.com> wrote:

Good afternoon,

I'm happy to report that I just talked with Judy, and she accepted the mission (in case you're wondering, the vetting issue was a mishap). This is great news because the Secretary wanted all of you to be able to contribute.

Let's make sure to include Judy in all of our correspondence from now on. The documents should be available here: https://www.dropbox.com/scl/fo/wahx6lpwzu33m5vyri8x/ANTU1qAQJ-zXCFzP_gsJcOs?rlkey=l1z3qj9v46e1t5f4ywwxq7p8c&e=1&dl=0. Please let us know if you don't have access.

Best,
Travis

On Fri, Apr 18, 2025 at 4:59 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

Thanks John. The quote from Mauritsen and Roeckner is a great addition.

I find the figure hard to follow, whereas the quote makes the point very clearly, in their own words.

On Fri, Apr 18, 2025 at 4:55 PM John Christy <climateman60@gmail.com> wrote:

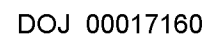
Ross

I've never been successful with dropbox and my record is still intact.

Attached is 1.6.2 to which I added a paragraph.

Also attached is a chart I annotated from AR6. I think this story demonstrates modelers are just playing with tuning parameters. Is there some way to use this information here (not necessarily in this format)?

John C.



Also to Travis' point we should look to having Judy help some of the sections. Travis, she can be reached via curry.judith@gmail.com

Ross

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Here is a Dropbox link that contains the current outline (also attached) which indicates who is working on each section

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Cheers,
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Steve is correct that this document should be clear and understandable for non-experts. My understanding is that it should also be sufficiently technical and comprehensive to inform policymakers on all relevant aspects of the science.

One area I can help with might be targeting your work for the very brief window we have open at the moment. I am including a few lines verbatim below from key documents to highlight the areas of

inquiry that are most relevant to the policymaking process. Of course, you all should make your own judgments about what to include versus what to leave out.

Here is a key section of the Clean Air Act, 202(a)(1): "The Administrator shall by regulation prescribe (and from time to time revise) in accordance with the provisions of this section, standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines, which in his judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare. Such standards shall be applicable to such vehicles and engines for their useful life (as determined under subsection (d), relating to useful life of vehicles for purposes of certification), whether such vehicles and engines are designed as complete systems or incorporate devices to prevent or control such pollution."

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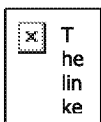
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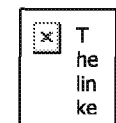
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<DE.memo.outline.Apr.11.[RM].docx>

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From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Friday, April 18, 2025 10:39 AM
To: Roy Spencer
Cc: Ross McKittrick; Steven Koonin; John Christy
Subject: Re: I'll need help: 10 sections to go

Thanks, Roy.

We have a few options here. I could do my best to summarize the published literature and add to the sections that need help (subject to close review from all of you), or we could enlarge the tent of scientists (or both). I recently learned that we can include Judith Curry, for example, so if you all are okay with that, I will loop her in. I need a good email and phone number for her—can anyone share that info with me?

If you see opportunities to enlist the help of others, please let me know.

Best,
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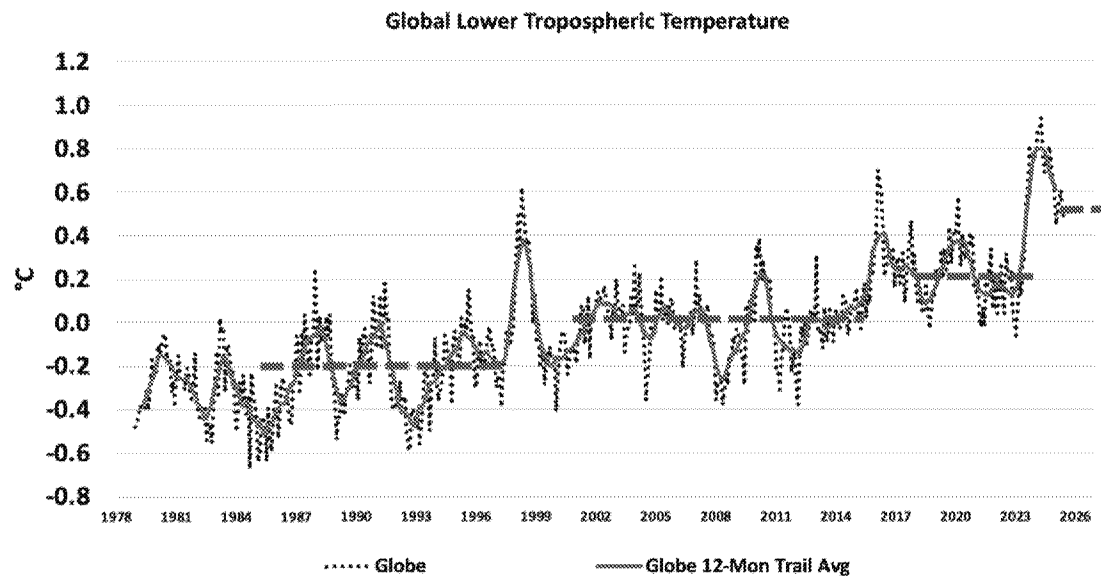
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Subject: Re: interesting new paper

Roy

Interesting. When you look at the global tropospheric temperature, you see an approximate rise of 0.2 C after every major El Niño.

John C.



On Wed, Jul 2, 2025 at 10:31 AM Roy Spencer <roywspencer@hotmail.com> wrote:
Many years ago we took the ARPS cloud resolving model (NSF-funded) and tried to modify it to conserve quantities for long climate runs. It would run for a number of years, then a warm event would cause the water vapor to increase, and it would find a new, warmer and more humid setpoint.

Then it would do it again some years later. Over and over again. Warmer and warmer.

This was a state-of-the-art model that grows individual clouds, thunderstorms, tornadoes, etc.

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Wednesday, July 2, 2025 9:21 AM
To: Steven Koonin <steven.koonin@gmail.com>
Cc: Judith Curry <curry.judith@gmail.com>; John Christy <climateman60@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Seth Cohen <seth.cohen@hq.doe.gov>; Josh Loucks <loucksj14@gmail.com>
Subject: Re: interesting new paper

SEK>>The experience in going from CMIP5 to CMIP6 does not auger well for improvements via increased resolution. It just increases the dimensionality of parameter space to be explored, hence creating more model uncertainty.

100% agree.

One of my other lines of work is managing a large Canadian macroeconomic model I built a few years ago for energy policy analysis. I recently increased the resolution of the investment sector to keep closer track of foreign investment flows by province. So a few dozen new parameters to identify with little empirical guidance except for some basic accounting identities. Out of nowhere the model started exhibiting lots of weird instabilities especially in long simulations out to 2050. Only a fool or a rogue would describe adding parameters to a model as an "improvement" unless it manifestly adds to forecast accuracy or some other objective gain in validity.

On Wed, Jul 2, 2025 at 10:04 AM Steven Koonin <steven.koonin@gmail.com> wrote:

You all might be interested in some comments on this paper that I sent to another colleague:

- I think they were too kind to the LSD (hallucinogenic?) approach by not showing its descriptive, let alone predictive, failures for global quantities – model spread of ECS and past century of GMST, hemispheric albedo asymmetry, mid-tropo warming, stratospheric cooling... And then failures for regional climates (e.g., US corn belt temperature trend)
- The experience in going from CMIP5 to CMIP6 does not auger well for improvements via increased resolution. It just increases the dimensionality of parameter space to be explored, hence creating more model uncertainty.
- AI/ML approaches should be pursued, but I will reserve judgement as to whether they'll be successful
- They're right that the program needs back-to-basics – more "theory", whether pencil-and-paper or reduced models. There's too much compute power and too few people who know how to think physically.
- Yes, this is more or less bog standard scientific method. Any credible climate realist might have written something along similar lines, although phrased less euphemistically. But would it have even been published?
- Slowly, slowly the tone is changing, as it also is in the energy world.

From: Judith Curry <curry.judith@gmail.com>

Sent: Thursday, June 26, 2025 12:30 PM

To: John Christy <climateman60@gmail.com>

Cc: Roy Spencer <roywspencer@hotmail.com>; Steven Koonin <steven.koonin@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>; Seth Cohen <seth.cohen@hq.doe.gov>; Josh Loucks <loucksj14@gmail.com>

Subject: interesting new paper

See attached, paper by Tiffany Shaw and Bjorn Stevens, two of the more intelligent mainstream climate scientists

The other climate "crisis" Which is basically about the failures of the existing paradigm. Maybe worth referencing in the CWG report?

.....



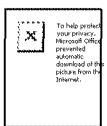
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From: Judith Curry <curry.judith@gmail.com>
Sent: Tuesday, August 5, 2025 6:28 PM
To: Ross McKittrick
Cc: Roy W. Spencer; John Christy; Steven Koonin; Josh Loucks
Subject: Re: Internal DoE responses compiled into 1 file

A few minor edits, but fine to just go with your version. Thx

On Tue, Aug 5, 2025 at 1:52 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:
just as Judy was sending her email I was about to hit send on this one. The attached Word document compiles all the responses into 1 file. It reflects my edits, Steve's edits and John's edits. Judy did you add any other changes?

--



Judith Curry, President
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curry.judith@cfanclimate.com | +1.404.803.2012
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From: John Christy <climateman60@gmail.com>
Sent: Saturday, July 12, 2025 3:11 PM
To: Steve Koonin
Cc: Ross McKittrick; Judith Curry; Roy W. Spencer; Travis Fisher; Josh Loucks; Cohen, Seth
Subject: Re: July 10 edition

To whomever is keeping up with the CWG corrections (Ross?)

I've just read through this version: DoE.Report.ERRATA.FIXED.July07 Curry SK

Errata (besides a few places with extraneous spaces)

Pg 54. Now "...of 1,211 CONU.S. stations designated...". Should be "... of 1,211 CONUS stations designated..."

Pg 96 top. Now "U.S. history occurred prior to the first half of the 20th century...". Should be

"... U.S. history occurred in the first half of the 20th century..."

Several places: "tonne" should be placed in glossary as "metric ton" or changed to "metric ton" in the text.

Frankly, I was amazed that between 11 April and 27 May (47 days) this document was created. My amazement recognizes the fact I contributed by far the fewest number of the 53,000 words. I did a lot of dataset building and number crunching, but that's just bookkeeping and arithmetic. Well done.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On Jul 12, 2025, at 9:05 AM, Steven Koonin <steven.koonin@gmail.com> wrote:

I've done another close read through it all. Changes indicated in the attached. Mostly typographical, but a few consequential and a very few questions.

SEK

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Thursday, July 10, 2025 10:54 PM

To: Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; John Christy <climateman60@gmail.com>; Steven Koonin <steven.koonin@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Josh Loucks <loucksj14@gmail.com>; Cohen, Seth <seth.cohen@hq.doe.gov>

Subject: July 10 edition

- errata fixed
 - Judy's edits accepted except the deletion of the 1st paragraph on p. 37 (extended IPCC quote) since deleting it wrecks the pagination and I think the extended quote is helpful.
 - The comment about policy in the exc summary is retained, and I think the economics chapter implicitly make the point
- With any luck this is the final version, until we change it again.

<DoE.Report.ERRATA.FIXED.July07 Curry SK.docx>

From: Judith Curry <curry.judith@gmail.com>
Sent: Wednesday, July 23, 2025 5:49 PM
To: Ross McKitrick
Cc: Fisher, Travis; Loucks, Joshua; Cohen, Seth; John Christy; Roy W. Spencer; Steven Koonin
Subject: Re: July 23rd version - final (?)

congrats to us all, and special thanks to RM for pulling it all together

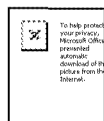
On Wed, Jul 23, 2025 at 2:19 PM Ross McKitrick <ross.mckitrick@gmail.com> wrote:

Attached in MSWord and PDF formats.

All of Steve's corrections incorporated, also John's stray L and everything else I'm aware of.

The only remaining correction I have not been able to make is using a high-res version of the DoE logo. If that becomes the main focus of public criticism I will say we did well.

Ross



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: John Christy <climateman60@gmail.com>
Sent: Thursday, June 12, 2025 3:17 PM
To: Steven Koonin
Cc: Ross McKittrick; Judith Curry; Roy W. Spencer; Travis Fisher; Josh Loucks
Subject: Re: JUNE 11 draft

All

I may be able to join you for a bit tomorrow at 0700 CT before we head to the airport.

I just reread the NASEM review of NCA5 Ch2 "Climate Trends". This was almost as stomach-churning as reading the NCA5 itself - a very soft review and just weird.

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Did you see this NASEM comment at the end of Chapter 2 review which seems to dissect the SLR portion about which you wrote? :

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Thanks, Ross.

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PS In case you all missed it, EPA/Zeldin today announced a relaxation of power plant emission rules:

https://www.wsj.com/politics/policy/epa-air-pollution-standards-repeal-1f85bf91?st=HnJKTD&reflink=desktopwebshare_permalink

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Oh, we're doing double work.

The attached is my latest integrated version, incorporating almost all of the changes Ross sent out yesterday, and my going through all of the sections.

We somehow need to reconcile these two.

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From: John Christy <climateman60@gmail.com>
Sent: Thursday, June 12, 2025 4:52 PM
To: Ross McKittrick
Cc: Steven Koonin; Judith Curry; Roy W. Spencer; Travis Fisher; Josh Loucks
Subject: Re: JUne 11 draft

Ross

I think it means - Make a map. Do significance testing on each grid (gaussian no doubt). Mask out the ones that are insignificant. Give the remaining grids a really bright, angry color to frighten the readers.

John C.

On Thu, Jun 12, 2025 at 3:14 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:
I agree that a separate chapter on the NASEM review would be an excellent addition.
John - I've no idea what "masking by T test means"

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Subject: Re: JUne 11 draft
Attachments: NCA5.Review.[RM][SK].June11.docx

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Review of the Fifth National Climate Assessment

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1 INTRODUCTION

1.1 About this Report

This report responds to a request from OSTP Director Michael Kratsios (reproduced in Appendix XX) that we assess the suitability of the Fifth National Climate Assessment for informing climate and energy policies.

To conduct this assessment we reviewed NCA5 itself, NASEM review of the Third Order Draft and the USGCRP responses to the review. We have drawn upon our long experience working on advisory reports, including for the NASEM, IPCC and other organizations, as writers, reviewers and project leaders.

Our report begins with background on the National Climate Assessments. We then discuss the standards by which we have assessed NCA5, followed by specific deficiencies that we have identified

We find that NCA5 should not be relied on for policy making as it is an incomplete and misleading picture of our understanding of the changing climate and the risks it poses to the nation. NCA5 was selective and incomplete in its survey of the science as of its publication date in 2023 and has become even more so in the years since. We have reviewed many key scientific developments in a separate report to Energy Secretary Wright (Climate Working Group 2025, herein denoted “CWG25”). The overall effect of the biases and omissions of NCA5 is an excessively dire picture of climate risk.

1.2 About the National Climate Assessments

The U.S. Global Change Research Program (USGCRP) was established by Presidential Initiative in 1989 and mandated by Congress in the Global Change Research Act (GCRA) of 1990 to develop and coordinate “a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.”

The National Climate Assessment (NCA) Reports evolved from the GCRA requirement to

Prepare and submit to the President and the Congress an assessment which (1) integrates, evaluates, and interprets the findings of the Program and discusses the scientific uncertainties associated with such findings; (2) analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity; and (3) analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years.

The five NCA Reports to date have interpreted this mandate in different ways:

- NCA1 (2000) was a multidisciplinary effort to study and portray in regional detail the potential effects of human-induced global warming on the United States.
- NCA2 (2009) was a relatively short report that not only focused on the potential consequences of climate change, but also sought to identify potential adaptation measures and identify the highest priorities for future research.
- NCA3 (2014) was an expanded effort that continued along the lines of NCA2, and was distinguished by a comprehensive review process, including a review by the National

Academy of Sciences. NCA3 introduced a traceability analysis for each key finding, including a description of uncertainties.

- NCA4 (2017/2018) was an expanded effort published in two volumes: I Climate Science Special Report, and II Impacts, Risk, and Adaptation in the United States. This was the first NCA report to devote significant effort to assessing climate science.
- NCA5 (2023) returned to a single volume format, reducing discussion of climate science to a cursory two chapters, with continuing with a focus on regional and sectoral impacts of climate change. NCA5 expanded its remit to topics that are arguably outside the purview of the USGCRP, focusing on “Climate Action” and policy recommendations with a social justice emphasis. NCA5’s self-description is reproduced as Appendix II.

These successive interpretations of the NCA are poorly aligned with the GCRA’s statutory requirements. Only NCA4 gives serious consideration to climate science, which receives the great majority of USGCRP funding, and even then misrepresents some important points. Natural climate variability is essentially dismissed as unimportant in NCA4 and barely mentioned in NCA5 in most contexts, despite the mandate to include both human-caused and natural climate change. Most significantly, NCA5 has redirected the focus away from climate science and even the hazard elements of impacts, towards evaluation of societal vulnerabilities and advocacy for particular policy options, especially wind and solar power. The cover image for the NCA5 Report is the installation of a solar panel.

1.3 Standards for Assessing NCA Products

In Appendix XX we include a letter of guidance from the Office of General Counsel, U.S. Department of Energy, summarizing the extent of statutory requirements governing USGCRP work products in general and NCA products in particular.

We can summarize the standards applicable to the NCA as follows:

- details.

Beyond the statutory requirements we draw attention to two other pertinent standards. President Trump’s executive order of May 23, 2025, “Restoring Gold Standard Science” enumerates some of the characteristics of good science:

- i. reproducible;
- ii. transparent;
- iii. communicative of error and uncertainty;
- iv. collaborative and interdisciplinary;
- v. skeptical of its findings and assumptions;
- vi. structured for falsifiability of hypotheses;
- vii. subject to unbiased peer review;
- viii. accepting of negative results as positive outcomes; and
- ix. without conflicts of interest.

Although these should be self-evident to those trained in science, it is surprising that some have found them controversial.

When scientific reports are being assembled that will be highly influential on climate policymaking there are other desiderata, including statements about the strength of climate knowledge. The IPCC's approach is based on judgment of the available evidence and agreement among experts. More sophisticated knowledge characterizations for risk management include (Aven 2017)¹:

- The degree to which the assumptions made are reasonable/realistic based on background knowledge
- The degree to which data/information exists and are reliable and relevant
- The degree to which there is disagreement among experts (including those from different environments or academic fields)
- The degree to which the phenomena involved are understood and accurate models exist
- The degree to which the knowledge has been thoroughly examined with respect to unknown knowns

Good climate and energy policies will balance the risks and benefits of a changing climate against the world's growing demand for reliable and affordable energy. To strike that balance, policymakers must understand at least two complex and nuanced topics: the certainties and uncertainties of climate science and the technoeconomic realities of energy systems. Experts in those subjects have a unique responsibility to communicate their understanding to non-experts clearly, completely, and without bias.

Expertise in energy systems resides largely in the private sector, where it is essential to providing the reliable and affordable energy services that are the lifeblood of society. Understanding is therefore continually refined and tested by the discipline of the marketplace. In contrast, climate science expertise is found largely in the non-profit realm of universities and government laboratories and so has a more academic character.

In recent decades, climate science has engendered passion and emotion. Indeed, some younger climate scientists have gone into the field to "save the planet." So it is not surprising that objectivity can suffer when climate scientists communicate their understanding to non-experts. Further, the field of climate science has been politicized by NetZero mandates. This lack of objectivity usurps the public's right to make informed choices and undermines their confidence in the scientific enterprise.

In 1980, then-President of the National Academy of Sciences Philip Handler identified the problem in an editorial² that resonates eerily four decades later:

Difficulty arises in the scientific community from confusion of the role of scientist *qua* scientist with that of scientist as citizen, confusion of the ethical code of the scientist with the obligation of the citizen, blurring the distinction between intrinsically scientific and intrinsically political questions. When scientists fail to recognize these boundaries, their own ideological beliefs, usually unspoken, easily becloud seemingly scientific debate.

¹ Aven, Terje (2017) "Improving Risk Characterisations in Practical Situations by Highlighting Knowledge Aspects, with Applications to Risk Matrices," *Reliability Engineering & System Safety* 167 (November 2017): 42–48 <https://www.sciencedirect.com/science/article/pii/S0951832016306950>

² Handler, Philip (1980) Public Doubts About Science. *Science* 208(4448) p. 1093 <https://www.science.org/doi/10.1126/science.208.4448.1093>

1.4 When Peer-Review Fails

Peer-review of reports like IPCC and NCA products is not a silver bullet that guarantees quality. The peer review process for these reports differs in some important respects from traditional peer review in academic journals. First, NCA reviewers self-select on a volunteer basis whether to provide comments and what parts of the report to read, whereas in academic journals Editors recruit reviewers and assign them to specific papers. There is no guarantee that any particular section of an NCA report was reviewed by anyone, let alone by someone with a different perspective than the authors. This is a problem with NCA and IPCC reports since over the years many potential reviewers have given up making the effort, because their input has systematically been ignored. Second, NCA authors have near complete authority whether to accept or reject review comments. Here, for example, is how a review comment critical of a section of the NCA5 draft was handled by the authors:

By contrast in academic journals the Editor mandates the author to respond and the reviewer gets to assess its adequacy. Once an NCA chapter author team has been selected publication of their work is guaranteed, whereas academic journals routinely reject papers if they do not pass review.

These points are important to bear in mind because some readers might dismiss any criticism of NCA products out of hand on the grounds that they were “peer reviewed”. But the test of a report is whether its contents are a valid representation of the available evidence. Here we give an example in which NCA4 gave prominence to a Figure that completely misrepresented the underlying data and which evaded peer review to do so. Further details can be found in Koonin (2024).

As we pointed out in CWG25 Section 6.3 the number of heat extremes in the U.S. peaked in the 1930s and has declined ever since. Considering cold and hot extremes together the U.S. the U.S. climate has become more moderate over time. NCA4’s Part I (Climate Science Special Report, CCSR) says (prominently and with *Very High Confidence*) on Page 19 of the Executive Summary:

There have been marked changes in temperature extremes across the contiguous United States. The number of high temperature records set in the past two decades far exceeds the number of low temperature records.

and offers this figure in support:

Record Warm Daily Temperatures Are Occurring More Often

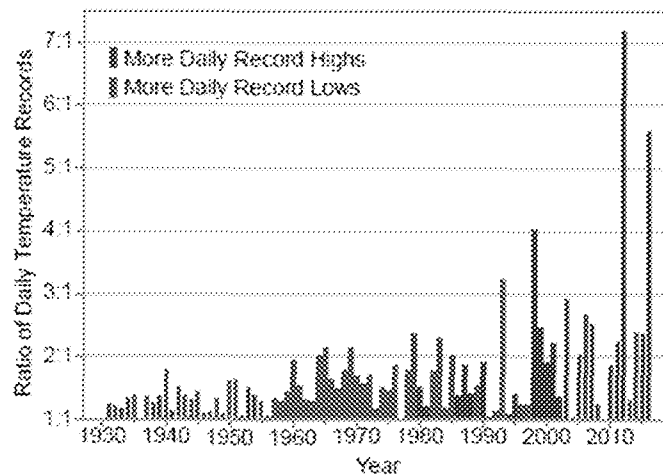
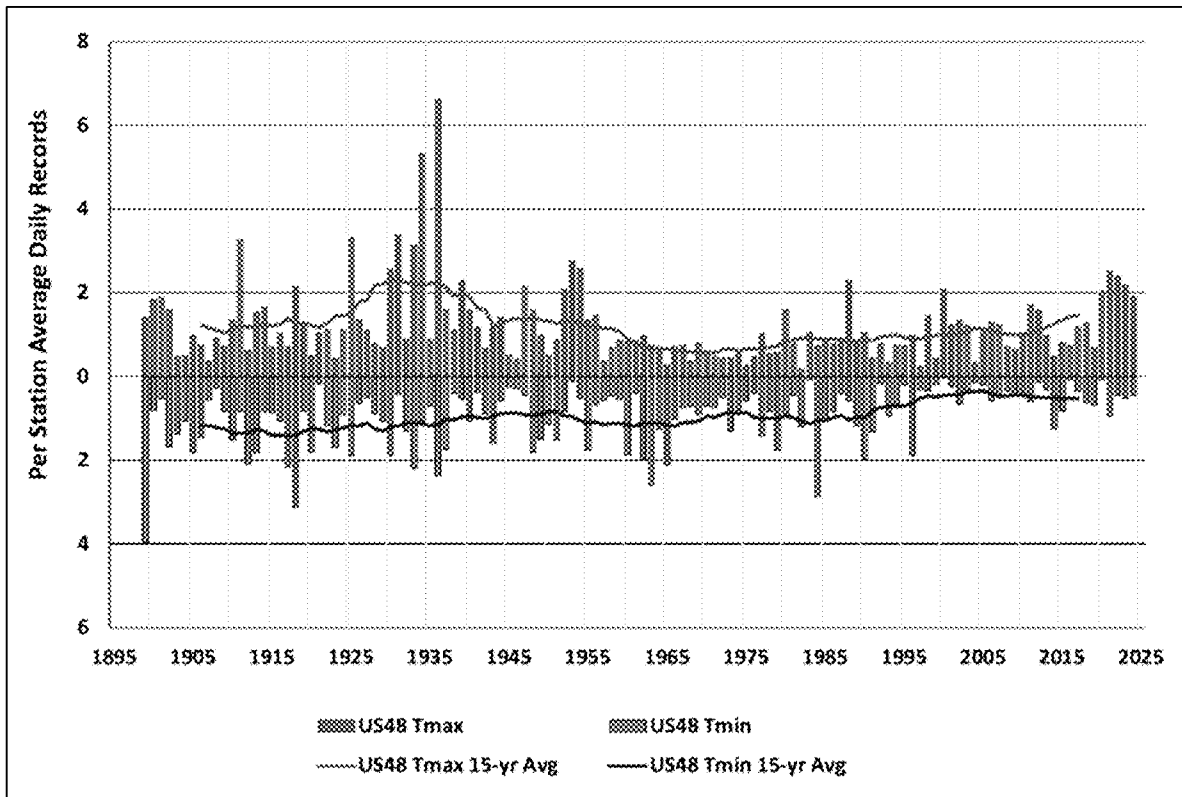


Figure ES.5: Observed changes in the occurrence of record-setting daily temperatures in the contiguous United States. Red bars indicate a year with more daily record highs than daily record lows, while blue bars indicate a year with more record lows than highs. The height of the bar indicates the ratio of record highs to lows (red) or of record lows to highs (blue). For example, a ratio of 2:1 for a blue bar means that there were twice as many record daily lows as daily record highs that year. (Figure source: NOAA/NCEI). From Figure 6.5 in Chapter 6.

The Figure appears to validate the claim that record warm daily temperatures are occurring more often. But the underlying data do not: they show that extreme heat in the U.S. peaked in the 1920s and 1930s and declined thereafter, as NCA4 Figure 6.4 itself later shows.

Figure ES.5 does not show what its title implies: these are not simple counts of cold and warm extreme events; instead they are ratios of the two. In fact, both types of extremes declined over the sample interval, but cold events declined more than warm events, so the ratio of warm extremes to cold extremes increased. By graphing the ratio in this way the NCA4 created a visual impression opposite to what is in the data.

Figure 6.3.3 of CWG25 (reproduced below) shows the results of a proper analysis of the data – defining each record as the singular extreme in the history, displaying numbers of warm and cold records separately, and beginning the analysis in 1899 rather than 1930. It makes evident the exceptional heat of the 1920s and especially the 1930s, peaking in 1936. The increased heat of the past five years is too brief to be deemed climatically significant and, in any event, occurred after the CSSR was published in 2017. The frequency of cold records has declined, especially over the last quarter of the period in which only 13 percent of the extreme cold events were measured. In contrast, 25 percent of the extreme Tmax records were achieved in the last quarter, which is consistent with statistical expectations. As a result, the ratio of heat to cold extremes shown in Figure ES.5 of the CSSR explodes in recent decades. The overall reduction in numbers of both cold and hot extremes over the past century indicates a climate *less* prone to extremes, in sharp contrast to the message of the NCA4 Figure ES.5.



Number of daily record High (red) and Low (blue) temperatures for warm and cold seasons in the CONUS. The lines represent the 15-year running, centered average. Source: 1,211 USHCN stations supplemented as needed to achieve a minimum of 92 percent of observations in the 126-year period since Dec 1898. US48: contiguous U.S. states. Tmax: maximum temperature. Tmin: minimum temperature. Source: CWG25 Figure 6.3.3.

The National Academies' expert review panel criticized the discussion of temperature extremes in a late draft of the CSSR. In reference to the CSSR's Key Finding 2 of Chapter 6, they said:

Further, it is difficult to understand how a statement that includes increases in extreme warmth can be associated with a high confidence or extremely likely statement, given that most of the graphics in this chapter show a decrease in extreme warmth in the historical record.

The Federal official in charge of the CSSR (Michael Kuperberg, Executive Director of the USGCRP) responded to the Academies' review by noting that

Almost every recommendation from the NAS was incorporated [in the final version]... and a new figure was added on changes in record high and low temperatures

The "new figure" referred to is the Figure ES.5, which did not appear in the draft reviewed by the Academies' panel. It seems unlikely that the Academies panel ever saw that figure because they surely would have commented if they had and it wouldn't have survived to publication. And the

figure's problems were evidently not flagged (or were ignored) in the subsequent internal government reviews.

With this background we now present our critique of NCA5.

2 NCA5 OVERVIEW CHAPTER: HYPERBOLIC ADVOCACY LANGUAGE AND NON-SCIENTIFIC TONE

NCA5 Chapter 1 “Overview” holds a prominent place in the Report since it summarizes the whole report and is the only section that many will read. Although the later Chapters of NCA5 contain much sound scholarly content, Chapter 1 is marred by a pervasive tone and language that aggressively promotes emission reduction policies. As such, this chapter adds an imprimatur of scientific authority to oversimplified declarations of opinion about public policy. Many examples can be cited; here we note a few that are particularly egregious.

Chapter 1 opens as follows:

The more the planet warms, the greater the impacts. Without rapid and deep reductions in global greenhouse gas emissions from human activities, the risks of accelerating sea level rise, intensifying extreme weather, and other harmful climate impacts will continue to grow. Each additional increment of warming is expected to lead to more damage and greater economic losses compared to previous increments of warming, while the risk of catastrophic or unforeseen consequences also increases.

This statement presupposes that: all warming is anthropogenic in origin, all warming is bad and causes economic damage, warming causes extreme weather to intensify. Such sweeping generalizations go well beyond what science has or can establish. It also refers to growing risks without saying whether they were large to begin with: a small risk that grows may still be a small risk. A scientifically-sound version of this paragraph would instead say something like the following:

The Earth is warming because of a combination of natural and anthropogenic influences. This warming will generate a mix of benefits and harms that varies by region, to which society should be prepared to adapt. Some types of extreme weather have worsened recently, while others have not changed or have even declined in intensity. Reducing emissions of greenhouse gases might slow the warming although such policies have proven to be costly and disruptive, so any climate actions to be weighed against the potential benefits.

On the next page the Overview goes on to say:

Each additional increment of warming leads to greater risks [here it lists 7 key components of society including food security and the economy]... Without deeper cuts in global net emissions, climate risks to the US will continue to grow... Action to limit future warming and reduce risks can have near-term benefits and opportunities: low-carbon energy jobs, Improved air quality, Health benefits, Economic benefits...”

The authors write as if climate policy does not involve trade-offs and all measures to reduce future warming will be effective and beneficial. But the vast body of scholarship on climate science and economics does not support such simplistic claims. Not every additional increment of warming leads to economic harms, indeed (as is acknowledged in Chapter 19 on Economics) in some cases there will be benefits. Nor is climate policy guaranteed to create jobs or benefit the economy; in many cases it has done the opposite. Such deceit is a disservice to policymakers.

Pages 8 and 9 promote renewable energy options by noting, correctly, that the levelized costs of wind/solar generation have fallen sharply since 2010. This is proposed as rationale for pursuing deep emission reductions:

Recent growth in the capacities of wind, solar, and battery storage technologies is supported by rapidly falling costs of zero- and low-carbon energy technologies, which can support even deeper emissions reductions. For example, wind and solar energy costs dropped 70% and 90%, respectively, over the last decade, while 80% of new generation capacity in 2020 came from renewable sources.

Yet it has long been known that intermittent renewables generation must be supplemented by dispatchable generation to meet grid reliability standards, and that doing so (e.g., through natural gas, fission, or storage) can substantially increase the cost of electricity. Further, there are yet unmet synchronization challenges in transmission grids with heavy penetration of wind and solar power. Here again it is advisory malpractice not to acknowledge these facts.

Page 14 presents future emission scenarios with the following description: “Climate modeling experts develop global climate projections for a range of plausible futures.” The word “plausible” is applied to all the scenarios. The accompanying Figure includes both SSP3-7.0 and SSP5-8.5, the latter reaching the same radiative forcing as RCP8.5. The figure does not contrast observed emissions against previous projections nor does it caution readers that SSP3-7.0 and SSP5-8.5 are extreme worst case scenarios that, like RCP8.5, have been heavily criticized in the scientific literature (CWG25 3.2.1). By describing the entire envelope of emission projections as “plausible” the report opens the door to later presenting impacts associated with extreme and implausible emission scenarios as part of a baseline “business-as-usual” future.

Page 17 introduces the discussion of risks from extreme weather events by saying “Harmful impacts from more frequent and severe extremes are increasing across the country.” This creates the impression that disaster losses are driven by trends in extreme weather. While the section goes on to acknowledge that some of the increase is due to increases in the value of assets at risk it then invokes the NOAA Billion Dollar Dataset as evidence of extreme weather getting worse. Scientists have shown that this is an invalid metric (CWG 10.2) since it measures the growth of the economy not the frequency of extreme weather, and indeed NOAA has recently withdrawn the data product. Even though it was still distributed by NOAA at the time of the NCA5, the report authors should have assessed it skeptically and seen that it was unfit for the purpose of measuring climate trends and they should have taken care not to conflate extreme weather metrics with economic trends.

Page 23 states, in large font:

Climate changes are making it harder to maintain safe homes and healthy families; reliable public services; a sustainable economy; thriving ecosystems, cultures, and traditions; and strong communities.

It is pointless to try to evaluate this statement on scholarly grounds; it is self-evidently hyperbolic. This kind of language doesn’t belong in a scientific assessment report. Its prominent inclusion points not only to the willingness of NCA5 authors to promote hysteria, but also the ineffectiveness of the review process at not ensuring such statements are removed.

The tone of the Overview chapter hints at the priorities that governed the writing of the report as a whole. As a crude indicator of these priorities, word searches of the full document revealed the following occurrences:

Term	Number of occurrences
Forcing	111
Uncertainty	384
Watts	19
Culture/culturally	854
Equity/equitable	572
Indigenous	890
Sustainable	295
Racism/racial	153

3 OVERCONFIDENCE WHEN STATING CONCLUSIONS

3.1 Inflated certainty levels

A general pattern in the NCA5 is overconfidence in stating conclusions. The authors frequently make sweeping generalizations without appropriate caveats or acknowledging uncertainties. The overconfidence begins with inflated language to describe certainty levels.

The NCA5 uses specific terms to convey information about scientific confidence associated with important finds, observations and projections. The Front Matter of the NCA5 states that “confidence in a finding is based on the type, amount, quality, strength, and consistency of evidence; the skill, range, and consistency of methods to detect, evaluate, attribute, and interpret climate trends; and the degree of agreement across scientific information sources.”

Table 1 from the Front Matter provides calibrated language for confidence assessment:

Very high:	Strong evidence (established theory, multiple sources, well documented and accepted methods, etc.). High consensus
High:	Moderate evidence (several sources, some consistency, methods vary and/or documentation limited, etc.). Medium consensus
Medium:	Suggestive evidence (a few sources, limited consistency, methods emerging, etc.) Competing schools of thought.
Low:	Inconclusive evidence (limited sources, extrapolations, inconsistent findings, poor documentation and/or methods not tested, etc.). Disagreement or lack of opinions among experts.

This terminology is inflated: *high confidence* with just moderate evidence and medium consensus; *medium confidence* with only suggestive evidence and competing schools of thought. This inflation in terminology leads to overconfidence in the conclusions.

Even within the context of this inflated terminology, NCA5 further inflates the confidence level of many of its conclusions to well beyond what the IPCC has concluded with more thorough justification, and also by incorrectly applying its own standards. Several illustrative examples are provided.

Key Message 3.1 Traceable Account states:

“There is *very high confidence* that emissions of GHGs from human activities, fossil fuel use in particular, have unequivocally caused *all* global warming observed over the industrial era.”

Compare this statement with statements from the IPCC AR5 and AR6:

AR5: “It is *extremely likely* that *more than half* of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together.” (IPCC, 2013)

AR6: The *likely* range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C. It is *likely* that well-mixed GHGs contributed a warming of 1.0°C to 2.0°C, other human drivers (principally aerosols) contributed a cooling of 0.0°C to 0.8°C, natural drivers changed global surface temperature by –0.1°C to +0.1°C, and internal variability changed it by –0.2°C to +0.2°C. It is *very likely* that well-mixed GHGs were the main driver of tropospheric warming since 1979.

The IPCC AR5 and AR6 statements provide likelihood assessments but not a confidence level. While the NCA5 claims with *very high confidence* that fossil fuels have unequivocally caused *all* global warming, the AR5 refers to “*more than half* of the observed warming” and the AR6 provides a more nuanced statement that relates to a *likely* range of warming contributed to by human drivers.

NCA5 Key message 2.2: “Hurricanes have been intensifying more rapidly since the 1980s (*high confidence*) and causing heavier rainfall and higher storm surges (*high confidence*).” No justification is provided in Chapter 2 for the *high confidence* conclusion on higher storm surges or hurricanes causing heavier precipitation. The Traceable Accounts section, Description of Confidence and Likelihood states:

Basic physical understanding and climate models both provide robust explanations for the links between climate change and observed changes in these extremes: this is why the authors also have *high confidence* that storms are delivering more rainfall and high confidence that storm surges are becoming higher.

In short, NCA5 provides no observational basis or published research for their *high confidence* assertions that hurricanes are causing heavier rainfall and higher storm surges; and does not meet its own standards for a *high confidence level*.

3.2 Overstating findings in underlying sources

Although we did not do a detailed audit of the NCA5’s use of source material, spot checks turned up evidence of a pattern of overstatement.

Chapter 2 page 11 reports on an increase in precipitation in some areas and attributes it to climate change:

Many eastern regions of the country are getting wetter (Figure 2.4). Average annual precipitation from 2002-2021 was 5%-15% higher relative to the 1901-1960 average in the central and eastern US, a trend attributable to climate change.

Note that this is a non-standard metric; we will discuss NCA5's inconsistent choices of time scales of analysis below. The claims were attributed to the following paper:

- Knutson, Thomas and Fanrong Zeng (2018) "Model Assessment of Observed Precipitation Trends over Land Regions: Detectable Human Influences and Possible Low Bias in Model Trends" *Journal of Climate* 31(12)
<https://journals.ametsoc.org/view/journals/clim/31/12/jcli-d-17-0672.1.xml>

But Knutson and Zeng did not say these things. They examined linear trends over 1901 – 2010, 1951 – 2010 and 1981 – 2010. They did not compare average rainfall over 2002 - 2021 to average rainfall over 1901 – 1960, indeed their study was published in 2018 so it could not have. With regard to 1981-2010 trends they noted stronger trends in some areas but cautioned that such changes are consistent with natural variability, and they did not claim attributable trends were observed over the United States:

Observed annual precipitation trends over the recent 30-yr period 1981–2010 (Fig. 5) have generally stronger magnitudes (in mm yr⁻¹ decade⁻¹) than observed trends for 1901–2010 or 1951–2010. This is as expected since trends over a shorter period have stronger potential for occurrence of pronounced temporary trends due to internal variability alone. Only 9% of the analyzed area has detectable and attributable anthropogenic influence (categories –3, –2, +2, +3), which represents less than one-third of the fractional areal coverage of such trends for 1901–2010 (29%). ... Eight percent of the analyzed area has attributable anthropogenic *increases* (categories +2, +3), including parts of eastern Europe, northern Asia, northern Australia/Maritime Continent, and tropical Africa.

Consider a 2nd example. NCA5 Chapter 2 page 18 states

There is robust evidence that human-caused warming has contributed to increases in the frequency and severity of the heaviest precipitation events across nearly 70% of the US.

This is attributed to two papers:

- Diffenbaugh, N.S., D. Singh, and J.S. Mankin, 2018: Unprecedented climate events: Historical changes, aspirational targets, and national commitments. *Science Advances*, 4 (2), 3354.
<https://doi.org/10.1126/sciadv.aao3354>
- Kirchmeier-Young, M.C. and X. Zhang, 2020: Human influence has intensified extreme precipitation in North America. *Proceedings of the National Academy of Sciences of the United States of America*, 117 (24), 13308-13313. <https://doi.org/10.1073/pnas.1921628117>

Diffenbaugh et al. presented ratios of observed occurrences of extreme events to simulated occurrence rates in CMIP6 models run with only natural forcings. They report that for 79% of the U.S. extreme rainfall event frequencies are currently higher than in model simulations, and the ratio of occurrences will rise under future warming simulations. This is not “robust” evidence of anthropogenic influence since it requires readers to assume that climate models provide accurate simulations of regional precipitation patterns, something which even the IPCC AR6 admits is uncertain (AR6 WGI SPM Box SPM 1.2, SPM Section C.1.3).

Kirchmeier-Young and Zhang looked at extreme 1- and 5-day events in North America and, using 3 GCMs, found “A signal of combined anthropogenic and natural external forcing can be detected in the intensification of extreme precipitation at the continental scale over North America. In some cases, this intensification can be attributed to human influence specifically.” However, they noted large differences among the three models in their simulated precipitation changes. Also, 2 of the 3 models failed to yield attribution for 5-day events for the North America mean, in other words the models disagreed on whether the observed changes were due to anthropogenic activity. Both cited references utilized the implausible RCP8.5 scenario and began their “historical” observational records only in 1961. Here again this is not “robust” evidence, it is suggestive but other studies have found natural variability predominant.

4 RELIANCE ON *Ad Hoc* TIME SCALES FOR TREND ANALYSIS

In CWG25 Chapter 6 we discussed the need to be careful regarding the choice of time scale when making claims about trends in extreme weather. We gave examples from analysis of river flooding (6.1), heatwaves (6.3) and extreme precipitation (6.4) to show how assertions about apparent trends based on short data sets fall apart when looking at longer versions of the same data sets. Here we elaborate on these examples to illustrate a general point that NCA5 made inconsistent and *ad hoc* choices about time scales of analysis, weakening the validity of their conclusions.

McKittrick and Christy (2019)³ showed that apparently significant positive trends in U.S. average and extreme precipitation over the NCA4 interval (1901 – 2016) disappeared on longer samples (extending back as far as the 1840s depending on location) or on a shorter interval coinciding with the final 40 years of the data then available (1978 – 2017).

In CWG Section 6.4 we presented analysis of updated data for the same locations and many more besides, in all cases finding both considerable regional heterogeneity and that trends detectable on one time scale are often not detected on longer or shorter time scales, which argues against simple attribution of changes to anthropogenic influences.

4.1 Average and Extreme Precipitation

Under Key Message 2.2 “Extreme Events Are Becoming More Frequent and Severe” (p. 2-16) NCA5 states (p. 2-18):

Rainfall is becoming more extreme

Since the 1950s, there has been an upward trend in heavy precipitation across the contiguous US. This increase is driven largely by more frequent precipitation extremes, with relatively smaller changes in their intensity.

NCA5 did not continue the NCA4 precedent of using the post-1901 interval as the time scale for its precipitation discussion, instead it refers to changes “since the 1950s”. Fig. 2.8 suggests 1958 as the start date. For the present report we have extended the CWG25 analysis even further to include 141 stations across the US in the Pacific Coast, Midwest, Northeast and Southeast regions. We provide details in Appendix XX; here we note merely that once again it is possible to find trends that support the NCA5 position, but they are not robust to selecting longer or shorter time scales of analysis. Data from 1950 to 2024 yields many indications of increased average and extreme precipitation at individual stations and region-wide averages. But when using the entire data set (back to the 1890s or earlier depending on location) or the later subset (1980 to 2024) the trends become smaller, in many cases they become statistically insignificant, and occasionally they change sign. Only in the Northeast region are the post-1950 trends robust to also focusing on the post-1980 interval.

The following is a more accurate summary of what U.S. data show.

³ McKittrick, R., and J.R. Christy (2019). Assessing changes in US regional precipitation on multiple time scales. *Journal of Hydrology*, 578, 124074. <https://doi.org/10.1016/j.jhydrol.2019.124074>

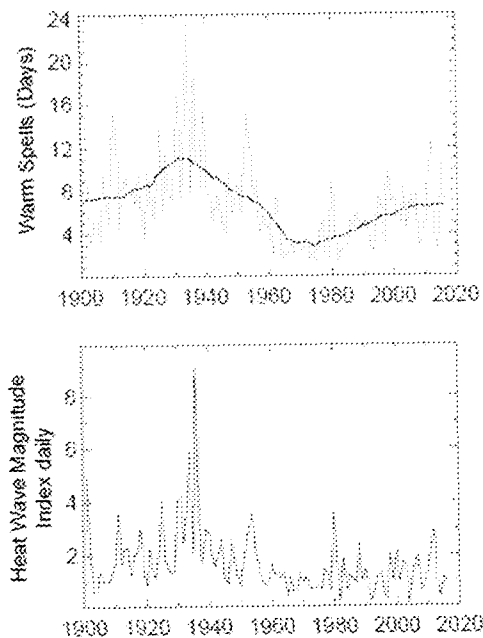
There are regionally-heterogenous changes in average and extreme precipitation. Positive trends in annual average rainfall and extreme events (defined either as the annual maximum or the number of exceedances of the 99th percentile value) are generally weak or non-existent when looking at samples exceeding 130 years in length. Significant trends can be found when beginning the sample in the 1950s although in most cases the trends weaken and become insignificant when looking at the post-1980 interval. This makes attribution to anthropogenic warming difficult.

4.2 Heatwaves

In contrast to NCA5, NCA4 examined heat extremes across the whole of the 20th century, pointing out that peak heat wave activity was reached in the 1930s and has decreased since then, and that recent increases are confined to areas west of the Rockies:

[The] warmest daily temperature of the year increased in some parts of the West over the past century, but there were decreases in almost all locations east of the Rocky Mountains. In fact, all eastern regions experienced a net decrease, most notably the Midwest (about 2.2°F [1.2°C]) and the Southeast (roughly 1.5°F [0.8°C]).

Since the mid-1960s, there has been only a very slight increase in the warmest daily temperature of the year (amidst large interannual variability). Heat waves (6-day periods with a maximum temperature above the 90th percentile for 1961–1990) increased in frequency until the mid-1930s, became considerably less common through the mid-1960s, and increased in frequency again thereafter. As with warm daily temperatures, heat wave magnitude reached a maximum in the 1930s. (NCA4 pp. 190-191)



U.S. Heat waves since 1900. Source: NCA4 Figure 6.4

Contrast this careful and factual language with NCA5 Key Message 2.2: “Extreme Events Are Becoming More frequent and Severe.” This blanket statement is followed by NCA5 Figure 2.7 reproduced below.

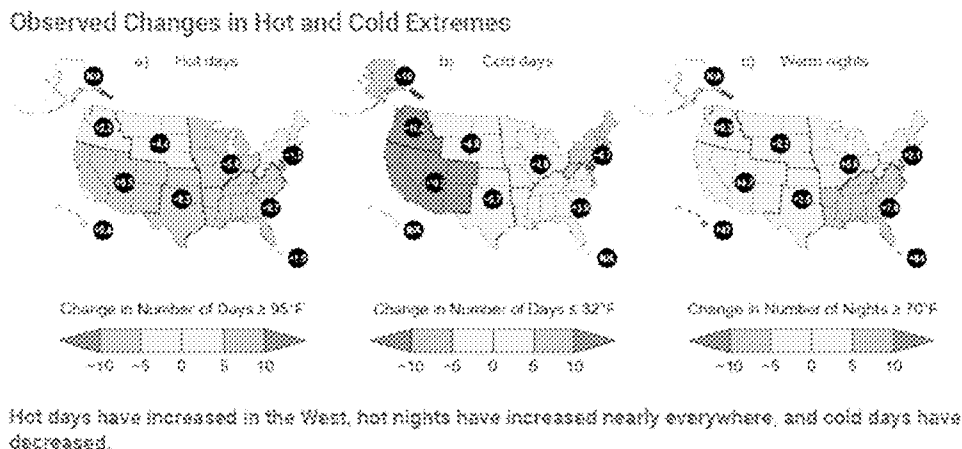


Figure 2.7. Over much of the country, the risk of warm nights has increased while the risk of cold days has decreased. The risk of hot days has also increased across the western US. This figure shows the observed change in the number of (a) hot days (days at or above 95°F), (b) cold days (days at or below 32°F), and (c) warm nights (nights at or above 70°F) over the period 2002–2021 relative to 1901–1960 (1951–1960 for Alaska and Hawaii and 1956–1980 for Puerto Rico). Data were not available for the US-Affiliated Pacific Islands and the US Virgin Islands. Figure credit: Project Drawdown, Washington State University Vancouver, NOAA NCIE, and CIRES NC.

Close inspection shows that this Figure contradicts the NCA5 Key Message with respect to heatwaves and instead reinforces the position of the NCA4. The time scale of analysis for this Figure is stated as the number of hot days, cold days and warm nights (respectively in panels a—c) over the period 2002–2021 compared to 1901–1960. Presumably (though not stated in the caption) the counts are per year. Notwithstanding Key Message 2.2 the leftmost panel shows that over most of CONUS the number of extreme heat days has decreased in recent decades compared to the prior century.

The accompanying discussion in NCA5 becomes convoluted since it appears to be aimed at supporting the Key Message despite the contrary evidence. NCA5 chapter 2 elaborates on KM2.2 by saying (p. 16):

Observations show an increase in the severity, extent, and/or frequency of multiple types of extreme events. Heatwaves have become more common and severe in the West since the 1980s (*high confidence*).

But it does not mention the decline elsewhere. On the next page (p. 17) it says:

By some measures, the most extreme heatwaves on record in the United States occurred during the Dust Bowl era of the 1930s. ... Globally such heatwaves are becoming more frequent, and in recent decades the western United States has been following those trends.

Reference to a global trend seems to be an attempt to tie heatwaves to climate change, but then the obvious question, unaddressed by NCA5, is why only part of the U.S. follows it while most of the

country is trending in the opposite direction. These issues were addressed in CWG25 Ch6, demonstrating that the range and magnitude of extreme temperatures (10s of degrees) are driven more by natural variability than the small extra forcing from the enhanced concentrations of CO₂. The data shown in CWG25 shows that in terms of both (a) hot days ($\geq 95^{\circ}\text{F}$) and (b) number of days in heatwaves, the current decade is experiencing no more than was experienced 100 years ago. For example, in the 30-year period 1925-1954, representing only 23% of the 1899-2024 data record, the CONUS experienced 33% of the total heat wave days. The most recent 30-years experienced 24%, almost exactly that expected by chance. Thus, the NCA5 claim that “multiday heatwaves have become hotter, more frequent, larger, and longer lasting in recent decades,” is seen to be simply false when expanding the temporal and spatial domains to encompass all available data (Ch6 Fig. 6.3.6 CWG25).

The NCA5 then pointed to the dramatic Pacific Northwest heatwave of 2021. CWG Section 8.6.1 discussed this event in detail, reviewing the findings of multiple peer-reviewed studies that explained the unusual meteorological conditions giving rise to it were unrelated to climate change, a point omitted from the NCA5 discussion.

NCA5 finally turns to the declining heatwave trend in CONUS east of the Rockies but attempts to reframe it by focusing on urban warm spells.

[The] number of very hot days has actually decreased across the central and eastern regions due to summer cooling trends in the region (Figure 2.7; Ch. 22). This does not, however, mean the central and eastern US are not affected by heat. The impacts of extreme high temperatures are more severe if such conditions persist for several days, and overall, multiday heatwaves have become hotter, more frequent, larger, and longer lasting in recent decades. Across 50 large US cities, the US Global Change Research Program heatwave indicator (<https://www.globalchange.gov/indicators/heat-waves>) shows that the average number of heatwaves has doubled since the 1980s, and the length of the heatwave season has increased from about 40 days to about 70 days.

We discussed this issue in CWG25 Section 6.3. The Figure referenced by NCA5 uses an *ad hoc* definition of heat wave, namely two consecutive days with minimum nighttime temperatures above the 85th percentile, and an *ad hoc* time scale which begins in the 1960s, the coldest decade in the last century, thus suppressing any comparison to the 1930s. Nighttime temperatures in urban areas have gone up faster than daytime temperatures (which the NCA5 acknowledges), but this is a signature of urban heat island effects and is not a good metric of climate change. CWG25 noted as well that the occurrence of hot days ($\geq 95^{\circ}\text{F}$) has recently increased in the West, but declined in the remainder of the country, and in the nationwide average, since 1899.

5 INADEQUATE TRACEABLE ACCOUNTS

Starting with the NCA3, the NCA has included a section on Traceable Accounts at the end of each Chapter. This is the description from the NCA5:

Each chapter concludes with a section entitled Traceable Accounts, which provides information on the overall process used to develop the chapter as well as a separate Traceable Account section for each Key Message. These Traceable Accounts describe the supporting evidence behind each Key Message, the process and rationale authors used in reaching their conclusions, and the author team's expert assessment of the confidence in and, where applicable, likelihood of these conclusions. As such, Traceable Accounts provide information about the state of the science, document sources of uncertainty, identify research gaps, and allow traceability to data and resources.

The Traceable Accounts for each Chapter and Key Message includes the following sections:

- Description of Evidence Base
- Major Uncertainties and Research Gaps
- Description of Confidence and Likelihood

The Traceable Accounts are in principle an important factor in addressing the NCA's statutory requirement to discuss scientific uncertainties. Further, the Traceable Accounts can help satisfy the Executive Order for Restoring Gold Standard Science with regards to: reproducibility, transparency, communication of error and uncertainty, and skepticism of findings and assumptions. However, the execution of the Traceable Accounts is uneven, often superficial and noninformative in Chapters 2 and 3 (which were the only Chapters investigated here). Here is an example from Key Message 2.2: Extreme Events are Becoming More Frequent and Severe.

The Description of the Evidence Base consists of two paragraphs, with the first paragraph summarizing the findings and the second paragraph providing a generic description of the types of data that can be used for storms. Major Uncertainties and Research Gaps focuses on the uneven distribution across US populations due to differences in exposure and vulnerability. The only limitations in data referred to are the lack of a long-term record of lightning, and the lack of homogenized daily and hourly temperature data except from reanalysis products.

The most astonishing deficiency is in the Description of Confidence and Likelihood. One of the statements in Key Message 2.2 is:

Hurricanes have been intensifying more rapidly since the 1980s (high confidence) and causing heavier rainfall and higher storm surges (high confidence).

The Description of Confidence and Likelihood includes the following statement:

Basic physical understanding and climate models both provide robust explanations for the links between climate change and observed changes in these extremes: this is why the authors also have high confidence that storms are delivering more rainfall and high confidence that storm surges are becoming higher.

No reference to journal publications or a specific data set is made in the Chapter regarding hurricane induced precipitation or storm surge to support this *high confidence* conclusion.

With regards to Chapter 3, there are some substantial inconsistencies between the Traceable Accounts for the different Key Findings:

Key Message 3-1: Human activities have caused global warming.

Confidence and Likelihood: “There is *very high confidence* that emissions of GHGs from human activities, fossil fuel use in particular, have *unequivocally* caused all global warming observed over the industrial era. There is also *very high confidence* that changes in natural climate drivers have had globally small and regionally variable long-term effects over this period.”

The Uncertainties section only addresses uncertainties in radiative forcing of greenhouse gases. By contrast, consider Key Message 3-4: “Humans are changing Earth System processes.” The Traceability Analysis in this section contains arguably the most scientifically credible text in the entire Chapter. From Description of Evidence Base:

In the last decade, there has been increasing recognition of the role of regional-scale natural variability in the past and future evolution of climate, as well as the fact that regional natural variability signals can be competitive with forced anthropogenic signals.

From Major Uncertainties and Research Gaps:

For example, the true natural variability of the climate system on decadal to centennial timescales could be larger than what we estimate from GCMs, which would further increase the irreducible uncertainty stemming from natural variability.

As part of the Traceable Account: “Each figure and some tables are accompanied by a metadata survey, which can be accessed in the online version of the report by clicking on the eyeball icon above the figure or table (see the table below for explanations of additional icons used throughout the report). The metadata survey describes data sources, figure or table development methods, copyright information, and other important documentation.” Upon clicking on the eyeball icon above a particular figure, a Contact US email appears, addressed to the USGCRP. No attempt was made to send a email to elicit the Metadata information, but it is clear that this information is not readily accessible online.

In summary, the Traceable Analyses examined here, with few exceptions, fail to meet the stated objectives set forward by the NCA.

6 OVEREMPHASIS ON EXTREME SCENARIOS

To respond to the GCRA mandate to “project major trends for the subsequent 25 to 100 years,” the NCA relies on projections of future climate change based on estimates of future emissions (the so-called SSP scenarios) and/or specified levels of radiative forcing (the RCP scenarios). For the most part, NCA5 uses scenarios developed for the IPCC Assessment Reports.

In CWG Section 3.2.1 we presented a critical assessment of past and current IPCC scenario envelopes, showing that they have tended to overshoot observed emissions. The IPCC AR6 published in 2021 stated that “The likelihood of high-emission scenarios like RCP8.5 and SSP5-8.5 is considered low in light of recent energy sector developments.” In 2021, UN Climate Negotiators (COP) stopped using scenarios above 4.5. NCA5 makes the following observations about the scenarios they use:

“NCA5 authors were advised to assess the full range of scenarios available.” (Front Matter)

“Scenarios of future emissions and land-use change are developed as plausible alternatives, but no relative likelihood is attached to them. Some recent studies, however, have argued that the highest scenario, SSP5-8.5, is no longer plausible without a reversal of current trends in the adoption of renewables and energy efficiency.” (Key Message 3.3 Traceable Analysis)

Despite acknowledging the issue the NCA5 otherwise ignored the problem. A keyword search of the NCA5 of mentions of RCP/SSP scenarios finds over 50% referred to the extreme emissions scenarios RCP8.5/SSP5-8.5. Further, 10 figures *only* included the 8.5 scenarios: 5.2, 6.9, 7.4, 11.3, 14.6, 22.13, 22.19, 27.9, 29.13.

The problem of relying on extreme scenarios is particularly acute for NCA5’s sea level rise projections. The sea level rise scenarios used in the NCA5 do not relate directly to the SSP emissions scenarios, but to specified amounts of sea level rise by 2100, whereby Low relates to 0.3 m (0.98 feet), Intermediate-Low relates to 0.5 m (1.64 feet), Intermediate relates to 1.0 m (3.28 feet), Intermediate-High relates to 1.5 m (4.92 feet), and High relates to 2.0 m (6.56 feet). (Table 4 of Guide to Using this Report).

Table 4. Descriptive Terms for Common Sea Level Rise Scenarios Used in NCA5

Future global mean sea level rise and sea level rise along United States coastline are shown for five scenarios in feet (and meters), relative to a 2000 baseline. The US values shown in the right half of the table are averaged across the US coastal regions, including the contiguous US, Alaska, Hawaii and the US-Affiliated Pacific Islands, and the US Caribbean. The national values shown in the table differ substantially from regional values. For example, sea level rise is higher in the Gulf Coast and lower or even negative in some parts of Alaska. In the next 100 years (2020–2050), sea level along the contiguous US coasts is expected to rise 0.92 feet (0.28 m), the same amount of sea level rise observed over the last 100 years (1920–2020). See Chapter 9 for regional sea level information. Adapted from Sweet et al. 2022.¹

Sea Level Rise Scenario Descriptor	Global Mean Sea Level			United States		
	2050	2100	2150	2050	2100	2150
Low	0.49 (0.15)	0.98 (0.3)	1.31 (0.4)	0.59 (0.18)	0.98 (0.3)	1.64 (0.5)
Intermediate-Low	0.66 (0.20)	1.64 (0.5)	2.62 (0.8)	0.75 (0.23)	1.64 (0.5)	2.95 (0.9)
Intermediate	0.92 (0.28)	3.28 (1.0)	6.23 (1.9)	0.89 (0.27)	3.28 (1.0)	6.89 (2.1)
Intermediate-High	1.21 (0.37)	4.92 (1.5)	8.86 (2.7)	1.12 (0.34)	4.92 (1.5)	8.86 (2.7)
High	1.41 (0.43)	6.56 (2.0)	12.14 (3.7)	1.38 (0.42)	6.56 (2.0)	12.46 (3.8)

CAPTION NEEDED

The text following is Judy's latest edit

Considering only projections representing processes quantified with at least medium confidence, the IPCC AR6 assessed global mean sea level projections for 2100 to fall between 0.2 and 1.6 m (5th—95th percentile range). Nevertheless, the range of sea level rise scenarios considered by the NCA5 extends to 2.0 m. Further, the NCA5 neglects to include plausible lower scenarios, such as 0.2 m cited by the IPCC, which also corresponds to the average rate of sea level rise over the past century.

With regards to actual predictions of sea level rise, Chapter 9 of the NCA states: “Under a range of potential global warming levels, average sea level along US coastlines is *likely* to be between 12 and 20 inches above 2000 sea levels in 2050.” These values of sea level rise encompass the Intermediate scenario to values slightly higher than the High scenario from NCA5 Table 4 shown above.

Global sea level rise projections to 2050 relative to a 2000 baseline can be evaluated with respect to the observed global sea level rise from 2000-2024, which is approximately 3.39 inches (0.28 feet). <https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level> Hence NCA5 is projecting values of sea level rise between 2025 and 2050 that are 3.5 to 5.8 times the rate observed during 2000-2024.

Chapter 9 further states: “Looking toward the future, an 11 inch (28 cm) average rise along the contiguous US coastline is expected by 2050 (relative to 2020), with a *likely* range of 9-13 inches.” With regards to confidence levels, NCA5 Chapter 9 Traceable Accounts states: “There is *high confidence* and it is *likely* that sea levels will rise about 11 inches (likely range of about 9–13 inches) between 2020 and 2050”

In summary, the NCA5 presents future sea level rise scenarios that are not directly relatable either to SSP/RCP emissions scenarios or Global Warming Levels. The NCA5 scenarios include some that are higher than the 95th percentile for the extreme emissions scenario RCP8.5 that include hypothesized ice sheet processes for which there is low confidence. Projections to 2050 require rates of sea level rise from 2025 to 2050 that are more than three times the rate observed during 2020-2024. Further, the NCA5 ascribes *high confidence* to these sea level rise projections.

In summary, the NCA5 inclusion, and even the focus, on implausible extreme emissions scenarios supports projections of alarming impacts that are very unlikely to be driven by anthropogenic warming.

7 BIASED SELECTION OF REFERENCES

THIS IS WHERE THE RP JR example should go.

8 SUMMARY: EVALUATION OF THE NCA5

8.1 Inadequate NASEM Review

The NASEM Review failed to raise the issues we have discussed herein. Much of it focused on social and policy issues (e.g., Comments on Equity and Justice), rather than on the underlying science. In our assessment NASEM failed to apply the serious rigor one would expect. A few extracted comments from it will illustrate. Note that NASEM review comments are included here in blue font for reference. NASEM praised Chapter 2, saying:

The chapter [2] meets the requirements of Section 106 of the GCRA.

Yet contrary to the requirements of Section 106 the NCA5 did not discuss natural variability let alone assess the full climate record available for quantifying natural variability. Chapter 2 actually minimizes natural variability by claiming (unsubstantiated) skill in attributing recent extremes to human causes. For example NCA5's Chapter 2 Introduction states,

"...recent advances in attribution science (KM 3.3) mean that the role of climate change in some extreme events can now be quantified in real time. For example, climate change made the record-breaking Pacific Northwest heatwave of June 2021 2° to 4°F hotter, and in 2017 ..."

CWG25 reviews the expert literature demonstrating that this particular event would have happened with or without climate change and that for the CONUS, hot extremes are no more frequent now than they were in the past. NASEM did not challenge the unsubstantiated attribution claims in the NCA5.

Notwithstanding NASEM's claim that the Chapter complies with Section 106 of the GCRA it then acknowledged the absence of discussion of natural variability:

...the discussion and references regarding the role of natural climate variability and its regional differences are missing.

While a nod to natural variability is occasionally found in NCA5, it is usually followed by a "however" to emphasize human influence. One example is the statement just before the claim mentioned above pertaining to extreme event attribution: "There has always been extreme weather, which occurs even in an unchanged climate due to the natural variability of the Earth system. However, recent advances in attribution science (KM 3.3) mean that the role of climate change in some extreme events can now be quantified in real time..."

We pointed out that the evidence regarding heatwaves directly contradicts Key Message 2.2. NASEM did not mention this, instead it focused on a somewhat esoteric issue of terminology:

"Extreme Events Are Becoming More Frequent and Severe."

Key Message 2.2 is another generally well written key message. However, while the title of this key message includes the word "risk," the key message is exclusively about hazard. The Committee suggests rewriting the key message title to more accurately reflect the discussion on hazards.

The NASEM review appears to accept the NCA5's use of short data records because it makes no critical remarks about the failure to assess long time series, except for its observation that the use of short records makes the omission of natural variability that much more of a problem:

It is also important to point out that the influence of natural climate variability becomes particularly strong when the climate trend is computed based on short periods of time or small geographic areas.

This comment was largely ignored in the NCA5 final text.

8.2 Pertinent aspects when evaluating NCA5 in light of statutory requirements

- not our remit to make a ruling but here are aspects to consider in light of statutory requirements

8.3 Evaluation from the perspective of expert users of the report

- we have deep knowledge of the topics surveyed by the NCA5 authors
- we do not have confidence that the report was balanced and comprehensive
- we can point to many specific instances in which the report did not exhibit an appropriate level of quality or integrity as a scientific document
- we have reason to believe the whole process, from author selection to handling of expert reviews, was biased towards reinforcing foregone conclusions and alarmist messaging

8.4 Evaluation from the perspective of citizens interested in good policymaking

- Public concerns about climate change are valid, as are concerns about cost of living, economic growth, employment, etc.
- We share the general concern that elected officials and those who serve them have the best information available when making important decisions around energy and climate policy
- NCA5 was a missed opportunity: it could have been a valuable input to that process but it did not turn out that way
- consequently its usage is unlikely to lead to better decisions and would more likely increase the error rate in policy formation and we recommend it not be used for policymaking purposes.

APPENDIXES

APPENDIX 1: Seth's letter on statutory requirements for NCA5

APPENDIX 2: Analysis of 141 U.S. Longterm Daily Precipitation Records.

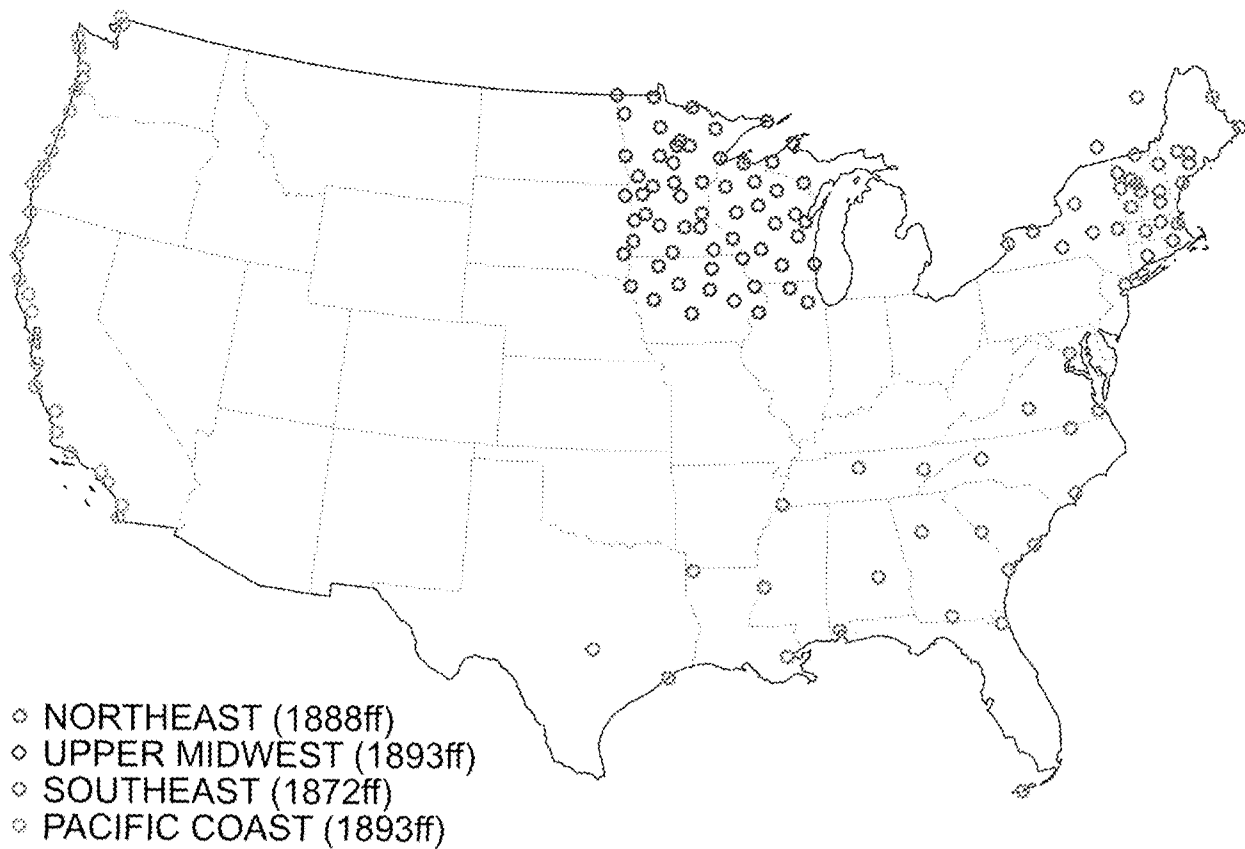


Figure. Stations used in the following analyses.

Table codes: (-) neg insignificant, -- neg significant, (+) pos insignificant, ++ pos significant.

Column 1: Measure

Column 2: Number of stations in that region

Column 3: Count of stations exhibiting a significant positive trend

Column 3: Count of stations exhibiting a significant negative trend

Column 5: Characteristic of region-wide trend

PACIFIC COAST

Since 1893:

	No. stns	+ trends	- trends	region
1-day average	29	0	1	(-)
2-day average	29	0	1	(-)
Avg on non-zero days	29	0	9	--
Variability	29	1	0	(+)
Annual max	29	2	1	(+)

Number of 99 th pct exceedances	29	1	0	(-)
--	----	---	---	-----

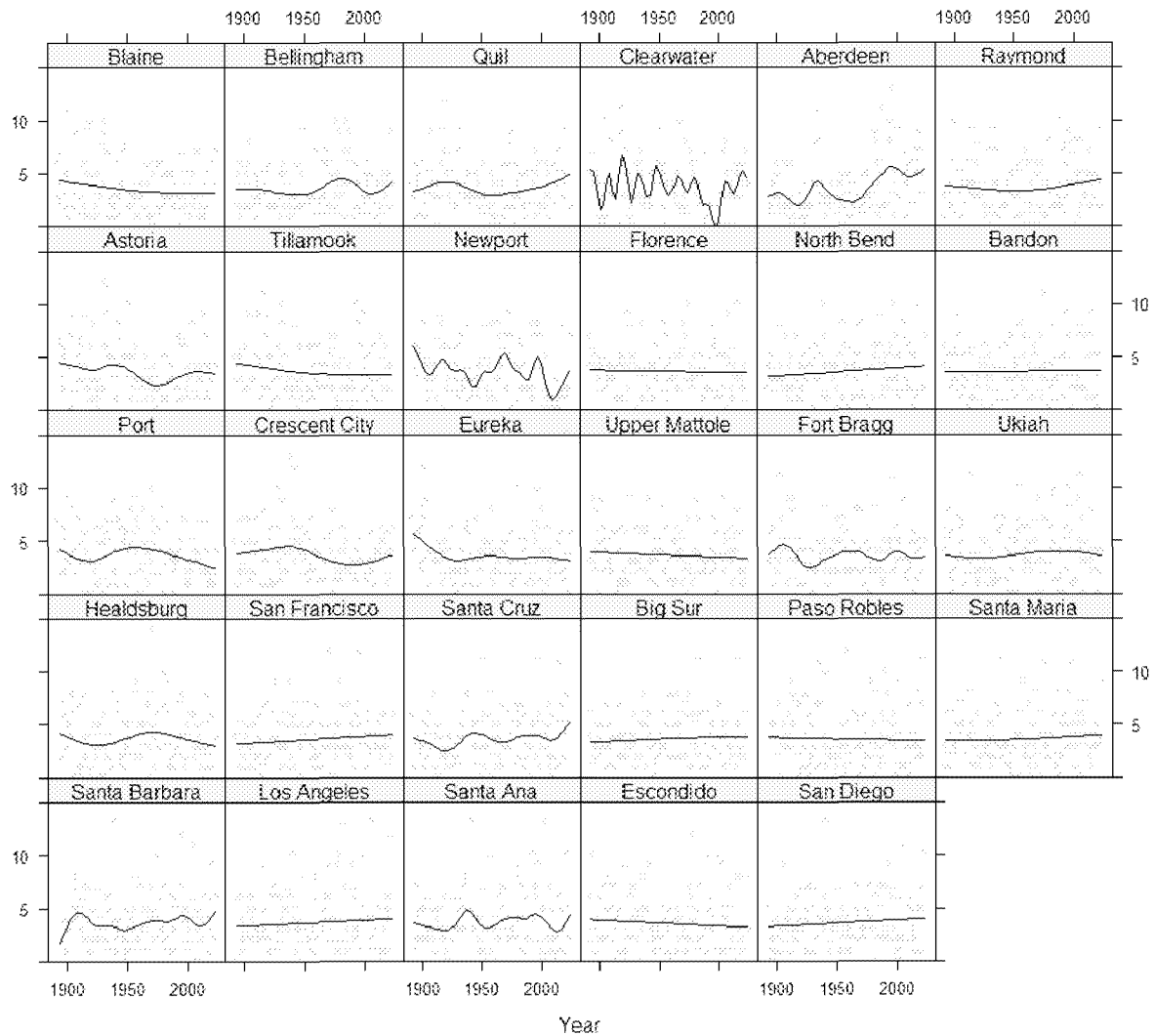
Since 1950:

	No. stns	+ trends	- trends	region
1-day average	29	0	1	(-)
2-day average	29	0	1	(-)
Avg on non-zero days	29	0	4	(-)
Variability	29	2	3	(-)
Annual max	29	6	3	(-)
Number of 99 th pct exceedances	29	2	1	(-)

Since 1980:

	No. stns	+ trends	- trends	region
1-day average	29	0	0	(-)
2-day average	29	0	0	(-)
Avg on non-zero days	29	0	1	(-)
Variability	29	0	0	(-)
Annual max	29	2	1	(-)
Number of 99 th pct exceedances	29	0	0	(+)

Annual No. 99th Percentile Exceedances PC 1893-2024



SOUTHEAST

Since 1873:

	No. stns	+ trends	- trends	region
1-day average	24	1	1	(+)
2-day average	24	1	1	(+)
Avg on non-zero days	24	7	2	(+)
Variability	24	1	0	(+)
Annual max	24	2	0	(+)
Number of 99 th pct exceedances	24	5	0	(+)

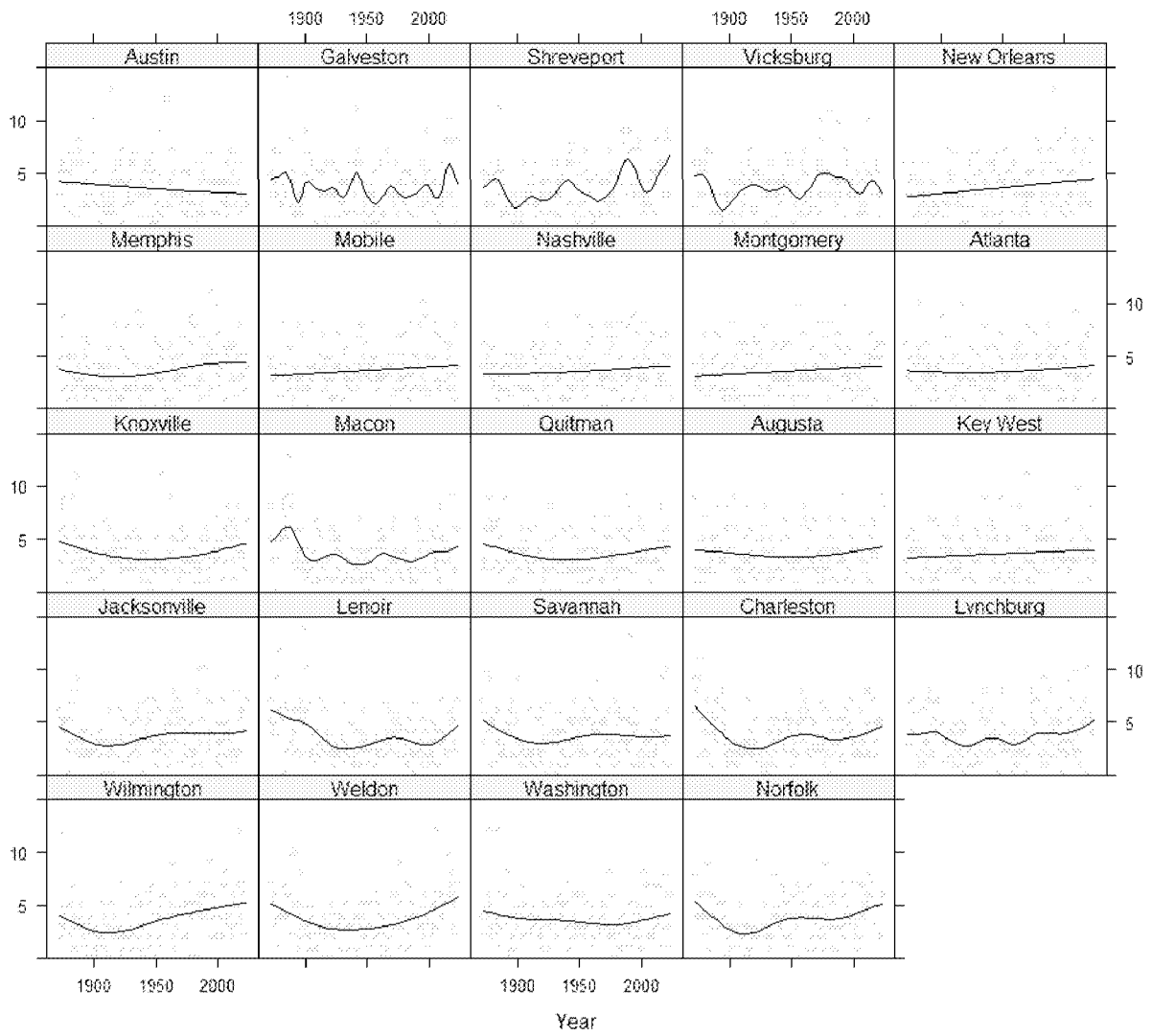
Since 1950:

	No. stns	+ trends	- trends	region
1-day average	24	5	0	++
2-day average	24	5	0	++
Avg on non-zero days	24	5	1	++
Variability	24	6	0	++
Annual max	24	4	0	++
Number of 99 th pct exceedances	24	4	0	(+)

Since 1980:

	No. stns	+ trends	- trends	region
1-day average	24	5	0	(+)
2-day average	24	5	0	(+)
Avg on non-zero days	24	5	1	(+)
Variability	24	3	0	(+)
Annual max	24	4	0	(+)
Number of 99 th pct exceedances	24	4	0	(+)

Annual No. 99th Percentile Exceedances SE 1873-2024



MIDWEST

Since 1893:

	No. stns	+ trends	- trends	region
1-day average	61	23	0	++
2-day average	61	23	0	++
Avg on non-zero days	61	2	12	(+)
Variability	61	12	0	++
Annual max	61	9	0	(+)
Number of 99 th pct exceedances	61	10	0	(+)

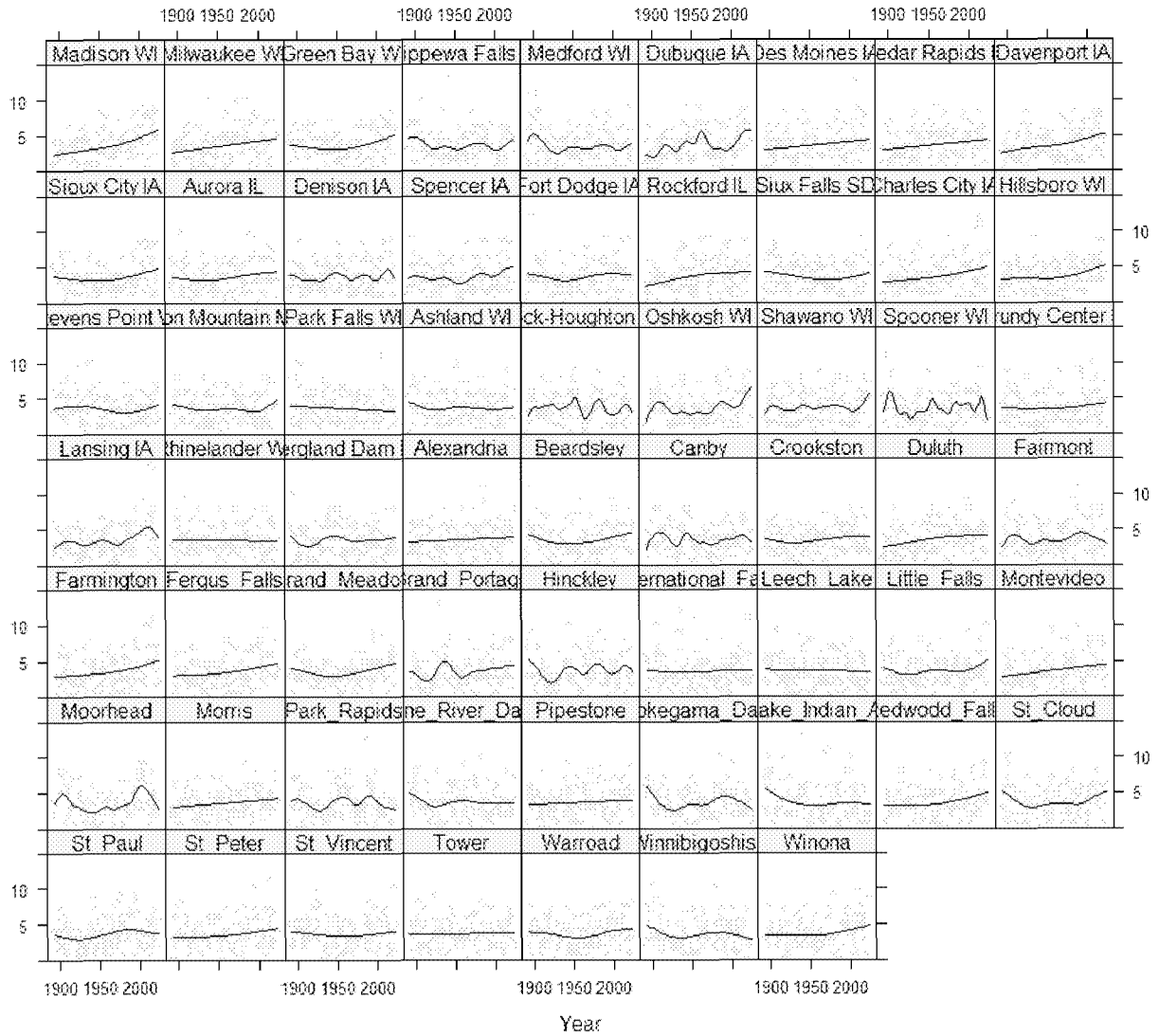
Since 1950:

	No. stns	+ trends	- trends	region
1-day average	61	28	2	++
2-day average	61	28	2	++
Avg on non-zero days	61	11	1	++
Variability	61	16	0	(+)
Annual max	61	8	0	(+)
Number of 99 th pct exceedances	61	19	0	++

Since 1980:

	No. stns	+ trends	- trends	region
1-day average	61	6	1	(+)
2-day average	61	6	1	(+)
Avg on non-zero days	61	8	2	(+)
Variability	61	5	1	(+)
Annual max	61	0	1	(+)
Number of 99 th pct exceedances	61	5	3	(-)

Annual No. 99th Percentile Exceedances MW 1893-2024



NORTHEAST

Since 1888:

	No. stns	+ trends	- trends	region
1-day average	27	12	0	++
2-day average	27	12	0	++
Avg on non-zero days	27	7	1	(+)
Variability	27	4	0	(+)
Annual max	27	3	0	(-)
Number of 99 th pct exceedances	27	5	0	(+)

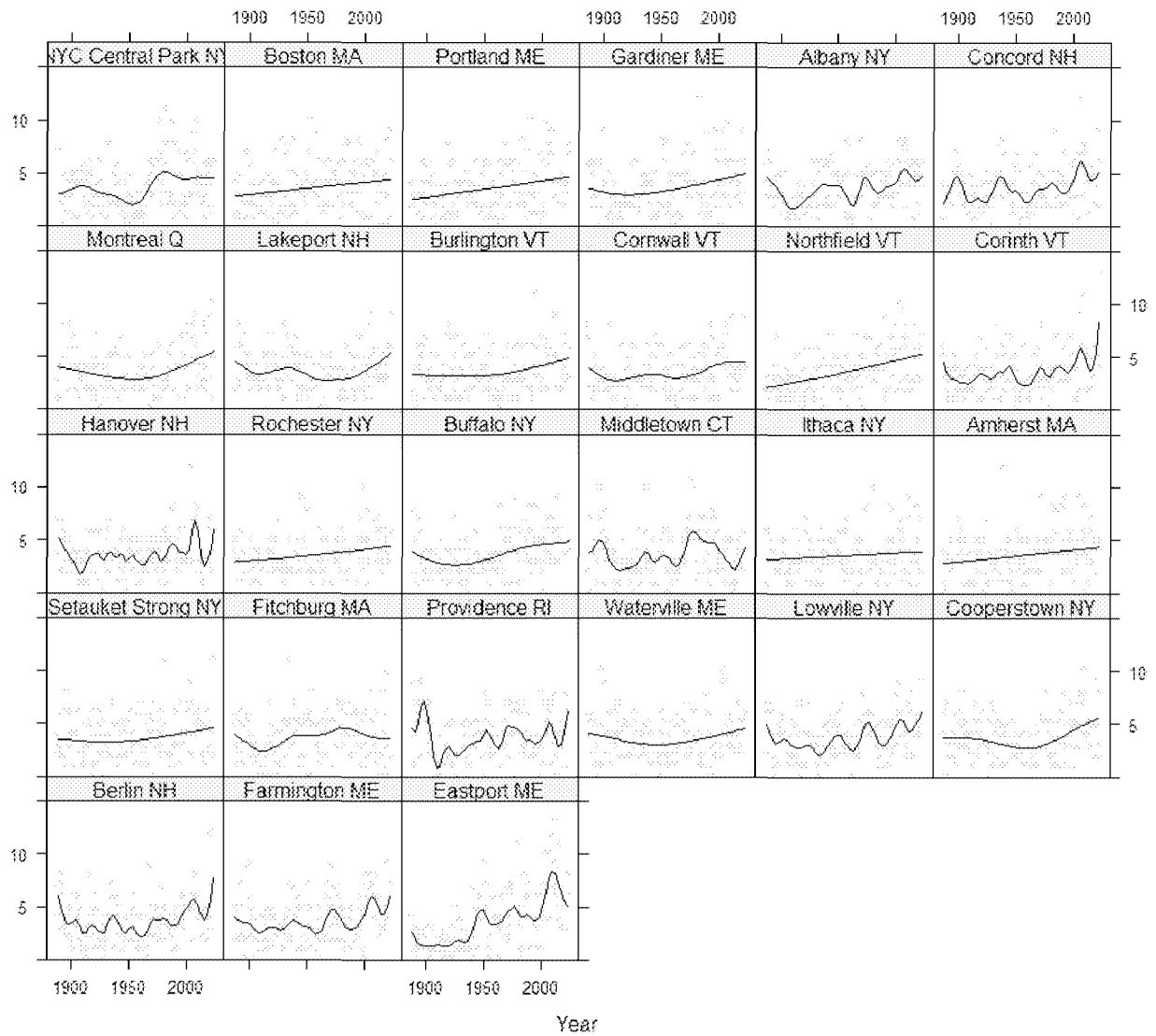
Since 1950:

	No. stns	+ trends	- trends	region
1-day average	27	12	0	++
2-day average	27	12	0	++
Avg on non-zero days	27	7	1	(+)
Variability	27	4	0	(+)
Annual max	27	3	0	(-)
Number of 99 th pct exceedances	27	5	0	++

Since 1980:

	No. stns	+ trends	- trends	region
1-day average	27	10	1	++
2-day average	27	10	1	++
Avg on non-zero days	27	6	0	(+)
Variability	27	2	0	(+)
Annual max	27	1	0	(+)
Number of 99 th pct exceedances	27	1	1	++

Annual No. 99th Percentile Exceedances NE 1888-2024



From: Judith Curry <curry.judith@gmail.com>
Sent: Saturday, June 7, 2025 6:44 PM
To: John Christy
Cc: Steve Koonin; Ross McKittrick; Roy W. Spencer; Travis Fisher; Josh Loucks; seth.cohen@hq.doe.gov
Subject: Re: June 7 NCA5 meeting follow up

For 2.2, I am adding hurricane example to Traceable Account section (forthcoming), so i don't think we need to say further about hurricanes. I would just pick one big whopper (i think quality is more important here than than quantity of examples).

On Sat, Jun 7, 2025 at 3:27 PM John Christy <climateman60@gmail.com> wrote:
All

How will we handle Key Message 2.2? This covers much of what we've analyzed. We've got heat waves, downpours, hurricanes and wildfires (Oh My!) here. This thing is a real target-rich environment.

[Key Message 2.2] Extreme Events Are Becoming More Frequent and Severe

Observations show an increase in the severity, extent, and/or frequency of multiple types of extreme events. Heatwaves have become more common and severe in the West since the 1980s (high confidence). Drought risk has been increasing in the Southwest over the past century (very high confidence), while at the same time rainfall has become more extreme in recent decades, especially east of the Rockies (very high confidence). Hurricanes have been intensifying more rapidly since the 1980s (high confidence) and causing heavier rainfall and higher storm surges (high confidence). More frequent and larger wildfires have been burning in the West in the past few decades due to a combination of climate factors, societal changes, and policies (very high confidence).

I like the last sentence that says to me, "Wildfires are increasing in the West due to increases in everything that makes wildfires increase."

Also, as evidence of wandering outside of the congressional guardrails how about all those sections on "Climate Action"

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On Jun 7, 2025, at 3:38 PM, Steven Koonin <steven.koonin@gmail.com> wrote:

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A few specifics:

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- Suggest we reconvene Tuesday June 10 at noon EDT (I'll be at Stanford). Let Josh know if that works for you.

Steve Koonin

<NCA5 report Jun7[SEK][JC].docx>



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: John Christy [climateman60@gmail.com]
Sent: 6/7/2025 11:17:51 PM
To: Judith Curry [curry.judith@gmail.com]
CC: Steve Koonin [steven.koonin@gmail.com]; Ross McKittrick [ross.mckittrick@gmail.com]; Roy W. Spencer [roywspencer@hotmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]; Josh Loucks [loucksj14@gmail.com]; seth.cohen@hq.doe.gov
Subject: Re: June 7 NCAS meeting follow up
Attachments: NCAS_KM_2.2_JRC_250607.0.docx; Untitled attachment 03683.htm

Is this what we are looking for? This is Key Message 2.2 without hurricanes in less than one page.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
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7 June 2025, 2312 GMT

NCA5 Key Message 2.2 *Extreme Events Are Becoming More Frequent and Severe*

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Our analysis indicates that most of what is said above regarding increases in extreme events is highly misleading and when extended spatially to the full CONUS and temporally to the late 19th century we find little in the way of significant changes (see CWG25 Ch6 for details). Specifically:

Observations from 1899 show that daytime heat extremes in the CONUS are no more common now than 100 years ago. However, nighttime temperatures have risen noticeably, related mostly to infrastructure growth around weather stations, so there are now fewer cold winter extremes than 100 years ago. As such, temperature extremes are becoming less frequent with the difference between hottest and coldest days each year shrinking by 5°F since 1899. While the West has experienced a recent increase in heat extremes, most of the CONUS has experience long-term declines. There are regionally-heterogenous changes in average and extreme precipitation. Positive trends in annual average rainfall and extreme events (defined either as the annual maximum or the number of exceedances of the 99th percentile value) are generally weak or non-existent when looking at samples exceeding 130 years in length. Significant trends can be found when beginning the sample in the 1950s although in most cases the trends weaken and become insignificant when looking at the post-1980 interval. [For hurricanes see XXX]. The incidence of CONUS wildfires is primarily a result of fire-suppression practices and were much more frequent 100 years ago and especially prior to the 19th century.

On Jun 7, 2025, at 5:43 PM, Judith Curry <curry.judith@gmail.com> wrote:

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Also, as evidence of wandering outside of the congressional guardrails how about all those sections on "Climate Action"

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<http://www.cfanclimate.net>

From: Judith Curry <curry.judith@gmail.com>
Sent: Sunday, June 8, 2025 10:58 AM
To: John Christy
Cc: Steve Koonin; Ross McKittrick; Roy W. Spencer; Travis Fisher; Josh Loucks; seth.cohen@hq.doe.gov
Subject: Re: June 7 NCA5 meeting follow up

Hi John, after thinking about this some more, Ross' suggestion about tying all these into endemic topics could work.

I put the main hurricane point into Traceability. A lot could go under Overconfidence. Even sea level rise could go under Emphasis on Extreme Scenarios. Much of the topics John and Ross have been looking at could go under Timeline or Misleading Metrics

If we are able to do it under endemic topics, I think it will be more effective, with clearer take home messages (not just that we don't like what they did with temperature, etc). And it will be less work for us if we just need a few whopper examples for each topic

So here are some endemic topics

Inadequate Traceable Accounts
Overconfidence in Conclusions
Emphasis on Extreme Scenarios
Misleading Metrics
(Short Timelines) not sure what to call that
Confusing Climate and Weather
Something about advocacy words
ETC

Your thoughts on this?

p.s. I'm working on overconfidence and extreme scenarios

On Sat, Jun 7, 2025 at 4:18 PM John Christy <climateman60@gmail.com> wrote:
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Subject: Re: June 7 NCA5 meeting follow up

Steve

The example of Pielke Jr, an internationally recognized expert on the topic for which his is brushed aside, points out what I've seen since being a key contributor on the 1992 IPCC report through being a Lead Author in 2001 and the many other climate panels with which I've had experience. It's a people problem. There is a sort of syndrome that develops in which authors who are selected for important projects somehow feel ordained with the "authority of the last word." I've found that those with least expertise have been most susceptible to this disease - and it points to a failure of skeptical peer review. At a minimum we can point out a couple of NCA5 examples but also demonstrate that we don't think of ourselves as the final word on climate science, that we welcome criticism and are willing to rewrite as needed. In truth, our ignorance of the climate system is enormous, and we are simply trying to get as far up as we can on the "what-we-actually-know" ladder that sits in a pool ignorance in which swim media-hype, career aspirations and political agendas. There are certainly more rungs above us to climb and we hope we can make a little progress in the upward direction.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On Jun 8, 2025, at 11:21 AM, Steven Koonin <steven.koonin@gmail.com> wrote:

Yes, endemic topics would be best if it can work. We could also then note how revealing it is when you re-read it having been sensitized to these deficiencies. We could also note these deficiencies (I'd really like to call them errors) are not subtle, but are elementary enough that they must be deliberate. And express surprise that they got by the NASEM review (or, if they were called out by NASEM, that USGCRP didn't correct them).

For the "short timelines", I think it would be better termed "Obscuring Historical Observations". That would include the short timelines, but also averaging the past in such a way as to minimize past variability (e.g., the temperature discussion of Fig 1.1a compares 2002-2021 with the average of 1901-1960

From: Judith Curry <curry.judith@gmail.com>
Sent: Sunday, June 8, 2025 10:58 AM
To: John Christy <climateman60@gmail.com>
Cc: Steve Koonin <steven.koonin@gmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Josh Loucks <loucksj14@gmail.com>; seth.cohen@hq.doe.gov
Subject: Re: June 7 NCA5 meeting follow up

Hi John, after thinking about this some more, Ross' suggestion about tying all these into endemic topics could work.

I put the main hurricane point into Traceability. A lot could go under Overconfidence. Even sea level rise could go under Emphasis on Extreme Scenarios. Much of the topics John and Ross have been looking at could go under Timeline or Misleading Metrics

If we are able to do it under endemic topics, i think it will be more effective, with clearer take home messages (not just that we don't like what they did with temperature, etc). And it will be less work for us if we just need a few whopper examples for each topic

So here are some endemic topics

Inadequate Traceable Accounts
Overconfidence in Conclusions
Emphasis on Extreme Scenarios
Misleading Metrics
(Short Timelines) not sure what to call that
Confusing Climate and Weather
Something about advocacy words
ETC

Your thoughts on this?

p.s. I'm working on overconfidence and extreme scenarios

On Sat, Jun 7, 2025 at 4:18 PM John Christy <climateman60@gmail.com> wrote:

Is this what we are looking for? This is Key Message 2.2 without hurricanes in less than one page.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On Jun 7, 2025, at 5:43 PM, Judith Curry <curry.judith@gmail.com> wrote:

For 2.2, I am adding hurricane example to Traceable Account section (forthcoming), so i don't think we need to say further about hurricanes. I would just pick one big whopper (i think quality is more important here than than quantity of examples).

On Sat, Jun 7, 2025 at 3:27 PM John Christy <climateman60@gmail.com> wrote:

All

How will we handle Key Message 2.2? This covers much of what we've analyzed. We've got heat waves, downpours, hurricanes and wildfires (Oh My!) here. This thing is a real target-rich environment.

[Key Message 2.2] Extreme Events Are Becoming More Frequent and Severe

Observations show an increase in the severity, extent, and/or frequency of multiple types of extreme events. Heatwaves have become more common and severe in the West since the 1980s (high confidence). Drought risk has been increasing in the Southwest over the past century (very high confidence), while at the same time rainfall has become more extreme in recent decades, especially east of the Rockies (very high confidence). Hurricanes have been intensifying more rapidly since the 1980s (high confidence) and causing heavier rainfall and higher storm surges (high confidence). More frequent and larger wildfires have been burning in the West in the past few decades due to a combination of climate factors, societal changes, and policies (very high confidence).

I like the last sentence that says to me, "Wildfires are increasing in the West due to increases in everything that makes wildfires increase."

Also, as evidence of wandering outside of the congressional guardrails how about all those sections on "Climate Action"

John C.

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On Jun 7, 2025, at 3:38 PM, Steven Koonin
<steven.koonin@gmail.com> wrote:

Attached is the latest draft that reflects discussion we had this afternoon, as well as edits Judy sent around a few hours ago.

A few specifics:

- Travis et al to work on the charge letter appearing in Appendix I
- Seth to produce some text summarizing legal guidance on NCA requirements and process
- We'll frame deficiencies as two types – endemic (with a few examples of each) and specific; perhaps try our hand at how we're rewrite key findings to reflect deficiencies we identify. Try to keep each item to a single page.
- Suggest we reconvene Tuesday June 10 at noon EDT (I'll be at Stanford). Let Josh know if that works for you.

Steve Koonin

<NCA5 report Jun7[SEK][JC].docx>

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<~WRD0030.jpg>

Judith Curry, President
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curry.judith@cfanclimate.com | +1.404.803.2012
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Sent: Saturday, June 7, 2025 6:27 PM
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<NCA5 report Jun7[SEK][JC].docx>

From: John Christy [climateman60@gmail.com]
Sent: 6/11/2025 3:08:56 PM
To: Ross McKittrick [ross.mckittrick@gmail.com]
CC: Judith Curry [curry.judith@gmail.com]; Roy W. Spencer [roywspencer@hotmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]; Steven Koonin [steven.koonin@gmail.com]; Josh Loucks [loucksj14@gmail.com]; seth.cohen@hq.doe.gov
Subject: Re: June 10 draft
Attachments: NCA5_Sec_4.2 Heat_Ext_JRC250611.0.docx

Steve and Ross

Not sure who is keeping the Master. Here is a slightly edited version of 4.2 Heat Extremes/Heat waves

John C.

On Wed, Jun 11, 2025 at 9:54 AM John Christy <climateman60@gmail.com> wrote:
Ross

Notes on version June10.

p. 4 Risk Management insert - is there a way to visually make the point that this insert has a general statement followed by an application to climate science. i.e.

The degree to which the assumptions made are reasonable, realistic based on background knowledge:
e.g., concern about the focus on implausible emissions scenarios RCP8.5/SSP5-8.5
etc.

p. 5 Do we have a citation for the Pielke Jr. comment? Can we seen responses to our public reviews?

p. 6 Steve, Ross: something needs to be said to further point out the deceptive figure: "The calculation of the values used in the ratio was unconventional in which records were cumulatively determined so a single day's record may appear several times in the figure. For example, a day, say 10 June, may have several appearances in the NCA4 figure as the record may be broken every decade or so, whereas CWG25 Fig 6.3.3 contains only one record for 10 June determined from the entire record and is plotted in the appropriate year." Something like that.

p. 6. "The increased heat of the past five years is too brief to be deemed climatically significant, WAS CONCENTRATED ONLY IN THE WEST, and, in any event, occurred after the CSSR was published in 2017."

I'll send something on heatwaves shortly.

John C.

On Tue, Jun 10, 2025 at 8:29 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

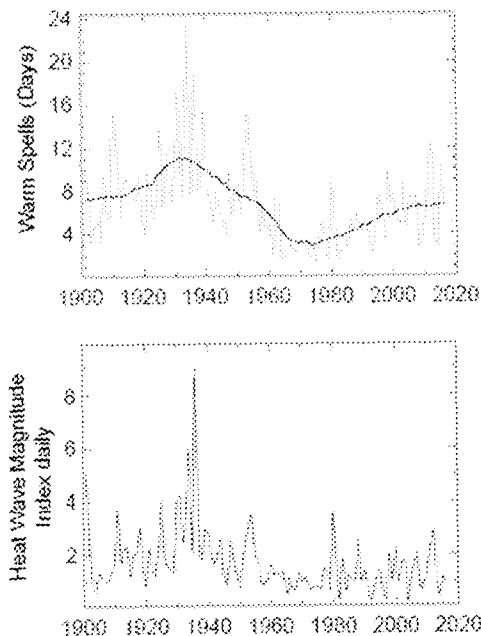
This incorporates all the material (I think) circulated by Judy and Steve today, along with some of my edits. It's also following a suggested organization and Table of Contents, but others may have suggestions for a better flow. .

Section 4.2 Heat Extremes

In contrast to NCA5, NCA4 examined heat extremes across the whole of the 20th century, pointing out that peak heat wave activity was reached in the 1930s and has decreased since then, and that recent increases are confined to areas west of the Rockies:

[The] warmest daily temperature of the year increased in some parts of the West over the past century, but there were decreases in almost all locations east of the Rocky Mountains. In fact, all eastern regions experienced a net decrease, most notably the Midwest (about 2.2°F [1.2°C]) and the Southeast (roughly 1.5°F [0.8°C]).

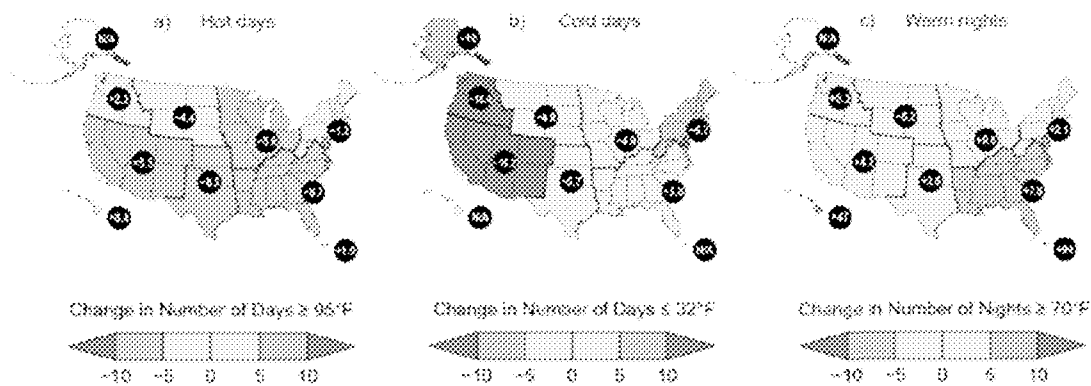
Since the mid-1960s, there has been only a very slight increase in the warmest daily temperature of the year (amidst large interannual variability). Heat waves (6-day periods with a maximum temperature above the 90th percentile for 1961–1990) increased in frequency until the mid-1930s, became considerably less common through the mid-1960s, and increased in frequency again thereafter. As with warm daily temperatures, heat wave magnitude reached a maximum in the 1930s. (NCA4 pp. 190-191)



U.S. Heat waves since 1900. Source: NCA4 Figure 6.4

Contrast this careful and factual language with NCA5 Key Message 2.2: “Extreme Events Are Becoming More frequent and Severe.” This blanket statement is followed by NCA5 Figure 2.7 reproduced below.

Observed Changes in Hot and Cold Extremes



Hot days have increased in the West, hot nights have increased nearly everywhere, and cold days have decreased.

Figure 2.7. Over much of the country, the risk of warm nights has increased while the risk of cold days has decreased. The risk of hot days has also increased across the western US. This figure shows the observed change in the number of (a) hot days (days at or above 95°F), (b) cold days (days at or below 32°F), and (c) warm nights (nights at or above 70°F) over the period 2002-2021 relative to 1901-1960 (1951-1980 for Alaska and Hawaii and 1956-1980 for Puerto Rico). Data were not available for the US-Affiliated Pacific Islands and the US Virgin Islands. Figure credit: Project Drawdown, Washington State University Vancouver, NOAA NCEI, and CISS NC.

Close inspection shows that this Figure contradicts the NCA5 Key Message with respect to heatwaves and instead reinforces the position of the NCA4. The time scale of analysis for this Figure is stated as the number of hot days, cold days and warm nights (respectively in panels a—c) over the period 2002-2021 compared to 1901-1960. Presumably (though not stated in the caption) the counts are per year. Notwithstanding Key Message 2.2 the leftmost panel shows that over most of CONUS the number of extreme heat days has decreased in recent decades compared to the prior century.

The accompanying discussion in NCA5 becomes convoluted since it appears to be aimed at supporting the Key Message despite the contrary evidence. NCA5 chapter 2 elaborates on KM2.2 by saying (p. 16):

Observations show an increase in the severity, extent, and/or frequency of multiple types of extreme events. Heatwaves have become more common and severe in the West since the 1980s (*high confidence*).

But it does not mention the decline elsewhere. On the next page (p. 17) it says:

By some measures, the most extreme heatwaves on record in the United States occurred during the Dust Bowl era of the 1930s. ... Globally such heatwaves are becoming more frequent, and in recent decades the western United States has been following those trends.

Reference to a global trend seems to be an attempt to tie heatwaves to climate change, but then the obvious question, unaddressed by NCA5, is why only part of the U.S. follows it while most of the country is trending in the opposite direction. These issues were addressed in CWG25 Ch6, demonstrating that the range and magnitude of extreme temperatures (10s of degrees) are driven more by natural variability than the small extra forcing from the enhanced concentrations of CO₂. The data shown in CWG25 shows that in terms of both (a) hot days ($\geq 95^\circ\text{F}$) and (b) number of days in heatwaves, the

current decade is experiencing no more than was experienced 100 years ago. For example, in the 30-year period 1925-1954, representing only 23% of the 1899-2024 data record, the CONUS experienced 33% of the total heat wave days. The most recent 30-years experienced 24%, almost exactly that expected by chance. Thus, the NCA5 claim that “multiday heatwaves have become hotter, more frequent, larger, and longer lasting in recent decades,” is seen to be simply false when expanding the temporal and spatial domains to encompass all available data (Ch6 Fig. 6.3.6 CWG25).

The NCA5 then pointed to the dramatic Pacific Northwest heatwave of 2021. CWG Section 8.6.1 discussed this event in detail, reviewing the findings of multiple peer-reviewed studies that explained the unusual meteorological conditions giving rise to it were unrelated to climate change, a point omitted from the NCA5 discussion.

NCA5 finally turns to the declining heatwave trend in CONUS east of the Rockies but attempts to reframe it by focusing on urban warm spells.

[The] number of very hot days has actually decreased across the central and eastern regions due to summer cooling trends in the region (Figure 2.7; Ch. 22). This does not, however, mean the central and eastern US are not affected by heat. The impacts of extreme high temperatures are more severe if such conditions persist for several days, and overall, multiday heatwaves have become hotter, more frequent, larger, and longer lasting in recent decades. Across 50 large US cities, the US Global Change Research Program heatwave indicator (<https://www.globalchange.gov/indicators/heat-waves>) shows that the average number of heatwaves has doubled since the 1980s, and the length of the heatwave season has increased from about 40 days to about 70 days.

We discussed this issue in CWG25 Section 6.3. The Figure referenced by NCA5 uses an *ad hoc* definition of heat wave, namely two consecutive days with minimum nighttime temperatures above the 85th percentile, and an *ad hoc* time scale which begins in the 1960s, the coldest decade in the last century, thus suppressing any comparison to the 1930s. Nighttime temperatures in urban areas have gone up faster than daytime temperatures (which the NCA5 acknowledges), but this is a signature of urban heat island effects and is not a good metric of climate change. CWG25 noted as well that the occurrence of hot days ($\geq 95^{\circ}$ F) has recently increased in the West, but declined in the remainder of the country, and in the nationwide average, since 1899.

The NASEM Review failed to raise any of these issues. Much of it focused on social and policy issues (e.g., Comments on Equity and Justice), rather than on the underlying science. In our assessment NASEM failed to apply the serious rigor one would expect. A few extracted comments from it will illustrate. Note that NASEM review comments are included here in blue font for reference. NASEM praised the section as a whole by saying:

The chapter [2] meets the requirements of Section 106 of the GCRA.

Yet contrary to the requirements of Section 106 the NCA5 did not discuss natural variability let alone assess the full climate record available for quantifying natural variability. Chapter 2 actually minimizes natural variability by claiming (unsubstantiated) skill in attributing recent extremes to human causes. For example NCA5’s Chapter 2 Introduction states,

“...recent advances in attribution science (KM 3.3) mean that the role of climate change in some extreme events can now be quantified in real time. For example, climate change made the record-breaking Pacific Northwest heatwave of June 2021 2° to 4°F hotter, and in 2017 ...”

CWG25 reviews the expert literature demonstrating that this particular event would have happened with or without climate change and that for the CONUS, hot extremes are no more frequent now than they were in the past. NASEM did not challenge the unsubstantiated attribution claims in the NCA5.

Notwithstanding NASEM’s claim that the section complies with Section 106 of the GCRA it then acknowledged the absence of discussion of natural variability:

...the discussion and references regarding the role of natural climate variability and its regional differences are missing.

While a nod to natural variability is occasionally found in NCA5, it is usually followed by a “however” to emphasize human influence. One example is the statement just before the claim mentioned above pertaining to extreme event attribution: “There has always been extreme weather, which occurs even in an unchanged climate due to the natural variability of the Earth system. However, recent advances in attribution science (KM 3.3) mean that the role of climate change in some extreme events can now be quantified in real time...”

We pointed out that the evidence regarding heatwaves directly contradicts Key Message 2.2. NASEM did not mention this, instead it focused on a somewhat esoteric issue of terminology:

“Extreme Events Are Becoming More Frequent and Severe.”

Key Message 2.2 is another generally well written key message. However, while the title of this key message includes the word “risk,” the key message is exclusively about hazard. The Committee suggests rewriting the key message title to more accurately reflect the discussion on hazards.

The NASEM review appears to accept the NCA5’s use of short data records because it makes no critical remarks about the failure to assess long time series, except for its observation that the use of short records makes the omission of natural variability that much more of a problem:

It is also important to point out that the influence of natural climate variability becomes particularly strong when the climate trend is computed based on short periods of time or small geographic areas.

This comment was largely ignored in the NCA5 final text.

From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Friday, June 20, 2025 4:48 PM
To: Roy Spencer
Cc: Steven Koonin; Judith Curry; Ross McKittrick; John Christy; Josh Loucks; Cohen, Seth
Subject: Re: June 20 docs
Attachments: 6-20-25 - USGCRP Framing Doc.docx

We have been asked by the suits to include in the tasking letter a reference to the forthcoming NCA6 process (to be more forward-looking).

Please let me know if you have any suggested edits to the attached markup. Also, if you want to hear the backstory, please feel free to call me at 202-302-9953.

I don't think this edit to the tasking letter will require changes to the report, but I do think it's fair game to include positive suggestions in the report like "NCA6 authors could avoid these errors by ____." Up to you all.

On Fri, Jun 20, 2025 at 3:23 PM Roy Spencer <roywspencer@hotmail.com> wrote:
Anthropogenic... Or Natural?

Sent from my Verizon, Samsung Galaxy smartphone

----- Original message -----

From: Steven Koonin <steven.koonin@gmail.com>
Date: 6/20/25 2:18 PM (GMT-06:00)
To: 'Judith Curry' <curry.judith@gmail.com>, 'Ross McKittrick' <ross.mckittrick@gmail.com>
Cc: 'Travis Fisher' <travis.scott.fisher@gmail.com>, 'John Christy' <climateman60@gmail.com>, "Roy W. Spencer" <roywspencer@hotmail.com>, 'Josh Loucks' <loucksj14@gmail.com>, "Cohen, Seth" <seth.cohen@hq.doe.gov>
Subject: RE: June 20 docs

On the title, something like “Conflation of anthropogenic and natural changes” might be better.

From: Judith Curry <curry.judith@gmail.com>
Sent: Friday, June 20, 2025 3:02 PM
To: Ross McKittrick <ross.mckittrick@gmail.com>

Cc: Travis Fisher <travis.scott.fisher@gmail.com>; John Christy <climateman60@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Steven Koonin <steven.koonin@gmail.com>; Josh Loucks <loucksj14@gmail.com>; Cohen, Seth <seth.cohen@hq.doe.gov>
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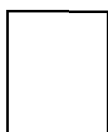
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DOCUMENT WITHHELD FOR PRIVILEGE

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Sent: Friday, June 20, 2025 5:51 PM
To: Travis Fisher
Cc: Roy Spencer; Steven Koonin; Ross McKittrick; John Christy; Josh Loucks; Cohen, Seth
Subject: Re: June 20 docs

Travis, we considered recommendations for NCA6 to be part of a follow on report. But since we do have several weeks yet, perhaps we could tackle this to some extent (but many are on travel in coming weeks).

One issue is that there is a fundamental flaw with the NCA mandate, and that is with regards to making projections 25 and 100 years into the future - climate models are not fit for this purpose. Another issue is that the term "global change" is ambiguous and is no longer in use for that reason. Personally I would recommend that the entire mandate be reconsidered. Failing that, we could make some specific recommendations in context of the existing mandate

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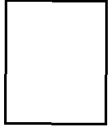
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From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Tuesday, July 1, 2025 9:36 PM
To: Ross McKittrick
Cc: Judith Curry; Steven Koonin; John Christy; Roy W. Spencer; Josh Loucks; Seth Cohen
Subject: Re: June 27 version of CWG report

We'll have a lot to discuss on Thursday!

For everyone's awareness, the draft notice of proposed rulemaking from EPA was circulated earlier today for interagency review. I expect more media questions to come given that the news of the policy change likely won't stay under wraps for long. I appreciate the close hold you all have had on this issue.

I'll elaborate on the process going forward and timelines etc. on our call. All I can say right now is rest assured your services will be in demand for the long haul!

On Tue, Jul 1, 2025 at 9:26 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:
She didn't contact me.

On Tue, Jul 1, 2025 at 8:28 PM Judith Curry <curry.judith@gmail.com> wrote:
likewise. Odd that she contacted all three of us?

On Tue, Jul 1, 2025 at 3:33 PM Steven Koonin <steven.koonin@gmail.com> wrote:
Same here.

Steven E. Koonin

On Jul 1, 2025, at 18:22, John Christy <climateman60@gmail.com> wrote:

All

Just turned down a request from a NY Times reporter to comment on the EF. Maxine Joselow.

John C.

On Tue, Jul 1, 2025 at 2:25 PM Steven Koonin <steven.koonin@gmail.com> wrote:

Now with some time back from vacation, I've gone through this version of the CWG report.

Suggested changes in the attached are mostly typos and minor wording. The few of more substance are highlighted in yellow with COMMENTS IN CAPS.

It IS a very good document. It will be interesting to see how it's received.

SEK

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Friday, June 27, 2025 9:49 PM
To: Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; John Christy <climateman60@gmail.com>; Steven Koonin <steven.koonin@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Josh Loucks <loucksj14@gmail.com>; Cohen, Seth <seth.cohen@hq.doe.gov>
Subject: June 27 version of CWG report

All errata fixed including Fig 5.7, all metadata listed.

Have a nice weekend everyone.



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Ross McKittrick [ross.mckittrick@gmail.com]
Sent: 4/14/2025 6:37:55 PM
To: Travis Fisher [travis.scott.fisher@gmail.com]
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Attachments: Table.of.Contents.Apr14.docx

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FOR DISCUSSION PURPOSES ONLY

**Current Scientific Understanding of US Greenhouse Gas Emissions from Motor
Vehicles as an Endangerment to US Citizens**

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	REFERENCES	ERROR! BOOKMARK NOT DEFINED.

From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Monday, April 14, 2025 2:58 PM
To: Steven Koonin
Cc: Ross McKittrick; John Christy; roywspencer@hotmail.com
Subject: Re: Kickoff

Excellent, thank you!

Yes, if you all have something to contribute to the definition of an air pollutant, I'd like to convey that to policymakers. I have no idea whether or not it will be included in whatever is ultimately published. One reason I ask is that the majority opinion in *Mass v. EPA* doesn't make sense to me -- it seems to over-include some classes of emissions that (to me, at least) are clearly not air pollutants. For example, both hydrocarbon- and hydrogen-fueled vehicles emit water vapor, but I'm not sure how many policymakers would find that water vapor is an air pollutant. Or is there a quantity threshold at which even water vapor becomes an air pollutant? These are the types of questions I expect to be part of the litigation, and any scientific input would be helpful to the policymaking process.

I look forward to helping this work get across the near-term finish line. If you have any questions about what's next or where your own paperwork is, etc., please call me anytime at 202-302-9953. For anyone who wants to continue to contribute to this project beyond this month, I am happy to report that we are figuring out ways to bring you on as a paid contractor. Special Government Employee status is a bit trickier, but we can likely make that work as well.

Also, I should clarify that I only play an attorney on TV. I appreciate the promotion from Steve, but I am not a lawyer (just an economist, and I'm not sure which is worse!).

Best,
Travis

On Mon, Apr 14, 2025 at 2:53 PM Steven Koonin <steven.koonin@gmail.com> wrote:
We need to be careful if we get into the issue of "what is/isn't a pollutant"

That's ultimately a legal question and we're not lawyers (well, Travis is).

I think we can legitimately compare/contrast the various properties of the pollutants cited (and water vapor!) such as effect, potency, lifetime, dispersion, ... That's consistent with our providing technical input.

But we shouldn't make any judgements - leave that for the lawyers and policy makers.

Steven Koonin (from New Delhi)

On Apr 15, 2025, at 00:08, Ross McKittrick <ross.mckittrick@gmail.com> wrote:

Hi Travis

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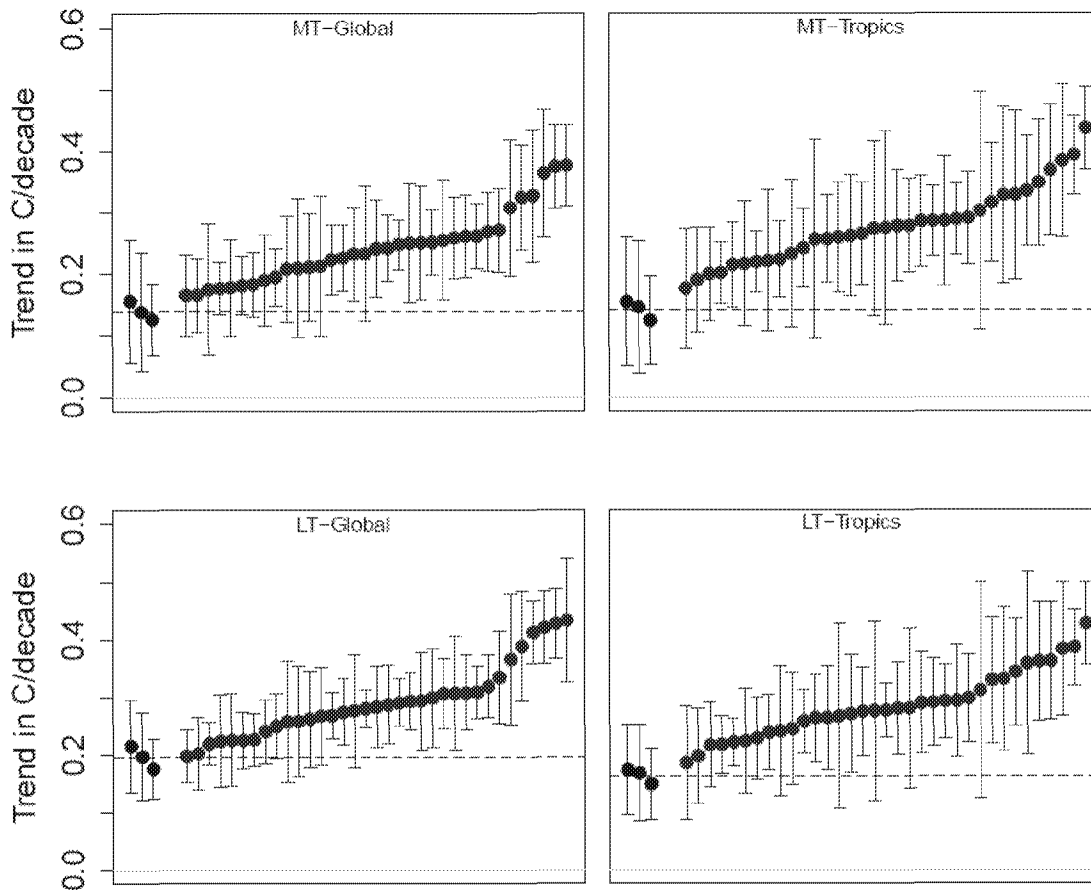
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From: Ross McKittrick [ross.mckittrick@gmail.com]
Sent: 5/21/2025 9:18:34 PM
To: John Christy [climateman60@gmail.com]
CC: Steve Koonin [steven.koonin@gmail.com]; Roy Spencer [roywspencer@hotmail.com]; Judith Curry [curry.judith@gmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]
Subject: Re: Late Edits.

Here's the trend comparison with the data updated to 2024. A bit more overlap in the LT. Most models still significantly too warm and the average model definitely so.
I'll make all these changes.



On Wed, May 21, 2025 at 5:06 PM John Christy <climateman60@gmail.com> wrote:
Ross:

Fig. 6.3.6 Caption. There are now only TWO regions compared - West vs. Central-East

pg 38, Text with Fig. 5.7. Observations are from Reanalyses, NOT Balloons (though balloons are part of the ingestion suite.) I did not use balloons because their geographic locations were so sparse as to create unneeded error when calculating large area averages. You might want to consider dropping balloons from your figures (also, they have not been bias corrected since before 2010).

Pg 50. Change NCA17 to NCA4 (2x)

Pg 51. TMax, TMin to Tmax, Tmin

PG 53 NCA17 to NCA4

Pg 54 NCA23 to NCA5

Pg 55 NCA17 to NCA4

Pg 56 change to "The excessive heat of the first half of the 20th century occurred primarily in the eastern two-thirds of the nation while the West has seen a recent increase of heatwave days (NCA5)."

Pg 56 NCA17 to NCA4

You could probably just do a global "Find/Change" for all NCA17s and NCA23s etc.

John C.

This is what David Robinson wrote 5 years ago about snow cover extent (SCE, related to section 5.6). I don't know that it adds anything except he was not pleased with the IPCC authors.

Hi John,

As you've already surmised, I was not part of this study. My impression was that the study was Arctic focused, but it seems as if the report may not have found all on the same page. The NOAA snow maps clearly show a continuation of declining snow cover extent (SCE) in spring. In particular, SCE has declined these past 15 years or so in May and June. SCE earlier in the spring first declined in the late 1980s and has remained on the lower side since then. Don't pay much attention to SCE in July and particularly August as I'm not as confident in the mapping back in the 1970s.

Fall is another question. This past decade has displayed increased October and November SCE. I believe this is legit, and a recent paper by Allchin and Dery (J. Climate) addressed this increase. However, there are folks in Canada (who contributed to the IPCC report) who believe the increased cover is an artifact of changed mapping procedures. They point out several other means of estimating SCE that don't show this increase. Fact is, the fall change does not coincide with a change in NOAA map production that occurred in the late 1990s (weekly, low res changed to daily higher res). I'm not saying that the NOAA mapping results have not been somewhat influenced by changes in mapping technology over the decades (this is, after all, an operational product that we climatologists have been left to use to the best of our abilities). However, I think there is something to the recent fall increases (winter hasn't changed all that much over the years) that warrants continued study (my thoughts turn to a more open arctic ocean for starters). I also remain confident in the spring SCE decline.

Hope these thoughts assist a bit.

Cheers,
Dave

Dr. David A. Robinson
Distinguished Professor &
New Jersey State Climatologist
Department of Geography &

NJ Agricultural Experiment Station
Rutgers University
54 Joyce Kilmer Avenue
Piscataway, NJ 08854-8045

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Thursday, April 17, 2025 10:40 AM
To: Steven Koonin
Cc: Roy W. Spencer; John Christy
Subject: Re: Late to the party

Hi Steve

If you are able to access the files in the Dropbox I suggest editing documents as you see fit (same goes for John and Roy) and saving it as a separate copy with date and initials. We'll end up with cumulative editions to wrangle but for now let's just get everything on paper. As the saying goes, if we had more time we could have written something shorter.

On Thu, Apr 17, 2025 at 10:10 AM Steven Koonin <steven.koonin@gmail.com> wrote:
Gentlemen:

Apologies for being absent, as I'm most of the way through an intense schedule in India (writing this from Mumbai).

I'll be able to pick up the metaphorical pen Saturday as I return to the US, so I'm wondering what's the best way to contribute. Sections in the outline with my name are only a few, and I'll knock those out pretty quickly. But scanning through what you've all written so far (which is excellent), I can see places where I'd want to add, tinker, edit, etc. Should I just copy a section, make edits with changes tracked, and leave it in my SEK Work folder? Or is there are master copy somewhere?

Steven Koonin

From: Roy Spencer <roywspencer@hotmail.com>
Sent: Tuesday, August 12, 2025 4:03 PM
To: Judith Curry
Cc: John Christy; Ross McKittrick; Steve Koonin; Jeremy T. Ison
Subject: Re: lawsuit

I rephrased your question to Grok:

https://grok.com/share/c2hhcmQtMw%3D%3D_37888a1a-83cc-4cfb-90c5-1193483b7036

From: Judith Curry <curry.judith@gmail.com>
Sent: Tuesday, August 12, 2025 2:56 PM
To: Roy Spencer <roywspencer@hotmail.com>
Cc: John Christy <climateman60@gmail.com>; Ross McKittrick <ross.mckitrick@gmail.com>; Steve Koonin <steven.koonin@gmail.com>; Jeremy T. Ison <jeremy.ison@hq.doe.gov>
Subject: Re: lawsuit

In reading through this, it seems a key issue for a FACA is to make recommendations to the govt. The CWG report did not do this, we should avoid making any recommendations in any future reports.

On Tue, Aug 12, 2025 at 12:47 PM Roy Spencer <roywspencer@hotmail.com> wrote:

Wow. That was fast. Much faster than 5 scientists can write a serious science report. Writing up a lawsuit must be somehow... easier.

-Roy

From: Judith Curry <curry.judith@gmail.com>
Sent: Tuesday, August 12, 2025 2:28 PM
To: John Christy <climateman60@gmail.com>
Cc: Ross McKittrick <ross.mckitrick@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; Steve Koonin <steven.koonin@gmail.com>; Jeremy T. Ison <jeremy.ison@hq.doe.gov>
Subject: lawsuit

have you spotted this

<https://library.edf.org/AssetLink/0kdlw6oq5v8hsvj152eqx01b0qn74uuq.pdf>

On Mon, Aug 11, 2025 at 8:25 AM John Christy <climateman60@gmail.com> wrote:

All

We have a mistake on page 90 first bullet. Arctic Sea Ice Extent - the link is to the Southern Hemisphere which shows a tiny decline, the link to the Arctic (change the "s" to an "n" in the link) shows 20 percent decline. This was pointed out by one of Cliff Mass's angry colleagues whom I will thank and ask to please put it in the public comments.

Arctic:

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Antarctic:

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John C.

On Wed, Aug 6, 2025 at 9:52 AM John Christy <climateman60@gmail.com> wrote:

All

I spoke with Cliff Mass who said he would be happy to be an expert reviewer. He's an elected Councillor of the AMS, is very well known and thus has creds.

I know Lindzen has a skeptic's baggage (as most of us do) but often has some clever insights in how to explain climate issues.

I haven't seen the most recent list of reviewer suggestions. Judy, could you send the list as a response to this email so we have a thread with a subject line dealing only with expert reviewers?

Thanks

John C.



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From: Ross McKittrick [ross.mckittrick@gmail.com]
Sent: 8/12/2025 10:49:30 PM
To: John Christy [climateman60@gmail.com]
CC: Steven Koonin [steven.koonin@gmail.com]; Judith Curry [curry.judith@gmail.com]; Roy Spencer [roywspencer@hotmail.com]; Jeremy T. Ison [jeremy.ison@hq.doe.gov]
Subject: Re: lawsuit

Well actually we are named, or at least the CWG is. Which sounds like they are suing us in our official capacity, except the suit claims we have no official capacity.
Since the remedy being sought involves the DoE and EPA taking action and the CWG ceasing to do anything it makes sense for the US to respond, presumably with a motion to dismiss.

On Tue, Aug 12, 2025 at 6:33 PM John Christy <climateman60@gmail.com> wrote:
Agree with Steve. We are not named as defendants, so it's up to DoE and EPA to deal with this.

John C.

On Tue, Aug 12, 2025 at 3:54 PM Steven Koonin <steven.koonin@gmail.com> wrote:
Just weighing in now. Suggest we let DOE lawyers handle this going forward and involve us as they think appropriate.

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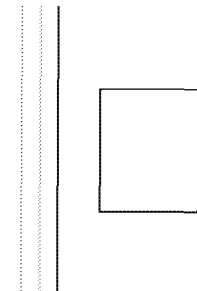
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To: John Christy
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Attachments: (6) Grok _ X.pdf

See attached analysis from Grok as to whether the CWG is a FACA or not

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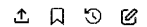
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curry.judith@cfanclimate.com | +1.404.803.2012
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Is the DOE Climate Working Group a FACA? provide arguments for and against

Thought for 49s

The DOE Climate Working Group (CWG), formed in 2025 under Energy Secretary Chris Wright, consists of five scientists tasked with producing a report evaluating the impacts of greenhouse gas emissions on the U.S. climate. This report has been used to challenge established climate policies, such as the EPA's 2009 Endangerment Finding. Whether the CWG qualifies as a federal advisory committee under the Federal Advisory Committee Act (FACA) is contested, with ongoing litigation highlighting the debate. FACA governs groups that provide advice or recommendations to federal agencies, requiring transparency, balanced membership, public participation, and formal chartering to prevent undue influence by special interests.

Arguments For the CWG Being Subject to FACA

- **Group-Based Advisory Role:** FACA applies when a group is convened to render collective advice or recommendations to a federal agency, rather than as individual contributors. The CWG was explicitly assembled as a group to produce a unified report advising the DOE (and indirectly the EPA) on climate science and policy implications, fitting this criterion per DOE's own internal guidance.
- **Lack of Required Processes Indicates Violation (Implying It Should Be Covered):** The CWG was hand-picked in secret by the Secretary, consisting of climate skeptics with fossil fuel industry ties, without a public nomination process, balanced representation of viewpoints, or opportunities for public comment. FACA mandates these elements for advisory committees, including public meetings and disclosure of materials, none of which occurred here—suggesting the group evaded FACA obligations while functioning as an advisory body.
- **Historical Precedent and Purpose of FACA:** Enacted in 1972 to address Nixon-era secrecy and special interest influence, FACA ensures advisory groups operate publicly. Litigation by groups like the Environmental Defense Fund and Union of Concerned Scientists argues the CWG's covert formation and use in policy challenges (e.g., rescinding the Endangerment Finding) mirror the abuses FACA was designed to prevent, making it a de facto advisory committee.

Arguments Against the CWG Being Subject to FACA

- **Not Formally Established as a Committee:** The DOE describes the CWG as a temporary assembly of "five independent scientists" convened for a specific, one-time report, rather than an ongoing formal committee. FACA typically applies to chartered groups with structured operations, and the CWG lacks such designation, potentially classifying it as ad hoc individual consultations rather than a collective advisory body.
- **Individual vs. Group Distinction:** DOE guidance exempts collections of individuals providing separate input from FACA, even if coordinated. Proponents of the CWG's formation emphasize it as a collaboration of hand-selected experts to highlight specific scientific perspectives without the bureaucracy of a full committee, avoiding FACA's requirements for public processes that could delay or dilute the effort.
- **Administrative Intent and Efficiency:** The group was formed quickly to address perceived gaps in climate discourse, with no intent to create a balanced or public-facing entity. Critics of applying FACA argue it would impose unnecessary hurdles on executive actions, and the absence of explicit chartering under FACA suggests the administration viewed it as outside the Act's scope, similar to internal working groups not subject to external oversight.

20 web pages



Quick Answer



Judith Curry
@curryja



Ask anything



From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Monday, April 21, 2025 4:16 PM
To: Ross McKittrick
Cc: John Christy; Roy W. Spencer; Steven Koonin; Judith Curry
Subject: Re: legal strategies

Thanks, Ross. I think the plan is to make a two-pronged argument (covering the strictly legal case and updating/revisiting the scientific underpinnings).

On Mon, Apr 21, 2025 at 3:49 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

This essay by Steve Milloy provides what seems to me a good explanation of why the Admin may want to move on the EF without a science paper
<https://issuesinsights.com/2025/04/21/no-due-process-for-illegal-regulations/>

In brief, they would leverage West Virginia vs EPA (Major Question doctrine) to argue that notwithstanding Mass vs EPA the EPA never had regulatory authority over GHGs so the EF was illegal.

It is more complex to argue that the science since 2010 invalidates the original EF. The danger is the Admin would implicitly be treating the original EF as legal. Given that it will likely go to SCOTUS the goal is to arrive there on the most favourable legal issue not a potentially weak issue concerning how a rule change was pursued. The Major Question doctrine appears to be favorable grounds to argue on.

From: Judith Curry [curry.judith@gmail.com]
Sent: 8/6/2025 4:28:58 PM
To: Steven Koonin [steven.koonin@gmail.com]
CC: Travis Fisher [travis.scott.fisher@gmail.com]; Ross McKittrick [ross.mckittrick@gmail.com]; Roy Spencer [roywspencer@hotmail.com]; John Christy [climateman60@gmail.com]
Subject: Re: List of external reviewers

I'm good with Inez and Gettleman

On Wed, Aug 6, 2025 at 8:22 AM Steven Koonin <steven.koonin@gmail.com> wrote:

Inez Fung at Berkeley is my go-to carbon cycle person. <https://vcresearch.berkeley.edu/faculty/inez-fung>

But perhaps she's already been one of our reviewers or is disqualified because of her joint position at LBNL?

From: Judith Curry <curry.judith@gmail.com>
Sent: Wednesday, August 6, 2025 11:15 AM
To: Travis Fisher <travis.scott.fisher@gmail.com>
Cc: Steven Koonin <steven.koonin@gmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; John Christy <climateman60@gmail.com>
Subject: List of external reviewers

Here is what we have so far (Cliff Mass is good, I would leave off Lindzen)

Lennaert Bengtsson

Isaac Held (Princeton, NAS)

Clara Deser (NCAR, NAS)

Graeme Stephens (NASA JPL, NAE)

Elizabeth Barnes (CSU, NASEM BASC; note she is also good with statistics)

Dan Shrag (Harvard, NAS?)

Richard Newell (economist)

Pielke Sr

Tim Palmer

Cliff Mass (AMS Council)

(statistician)

(carbon cycle person)

On Wed, Aug 6, 2025 at 8:11 AM Travis Fisher <travis.scott.fisher@gmail.com> wrote:

The article is live: <https://www.cato.org/blog/why-i-helped-organize-department-energys-climate-report>. If anyone wants to suggest it to the editors at WUWT, that would be fine by me (I don't really know them).

Thank you all for welcoming me into the liaison role. It was truly a career highlight!

On Tue, Aug 5, 2025 at 8:27 PM Steven Koonin <steven.koonin@gmail.com> wrote:

Travis – you write well – this is a fine piece.

It would be quite appropriate to see it on WUWT. And you might try publishing a somewhat shortened version in Real Clear Energy.

SEK

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Sent: Tuesday, August 5, 2025 4:17 PM

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Cc: Steven Koonin <steven.koonin@gmail.com>; roywspencer@hotmail.com; climateman60@gmail.com; Judith Curry <curry.judith@gmail.com>

Subject: Re: a defense of CWG25 in the Italian press

Ross, we had a quick call with the Secretary around 12:30. He thanked us all for our work, especially the CWG authors, and I emphasized your leadership role. Audrey said she and Chris would send you a video separately. I hope they do something ridiculous!

I'm attaching my write-up about this effort, which will be published at Cato and added to my Substack. If you have any concerns, please share them. I want to make sure everyone gets the credit they deserve and is comfortable with the way I talk about the effort.

I'll also run this by the DOE folks and try to publish it in the morning if possible.

On Tue, Aug 5, 2025 at 12:40 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

Sorry just seeing this. I'm on the road and unavailable until around 2.

On Tue, Aug 5, 2025 at 12:13 PM Travis Fisher <travis.scott.fisher@gmail.com> wrote:

Yes, look for a Google Meet link in one minute!

On Tue, Aug 5, 2025 at 12:07 PM Steven Koonin <steven.koonin@gmail.com> wrote:

I think Ross is incommunicado until later this afternoon. Is the meeting happening and, if so, how to connect?

SEK

From: Travis Fisher <travis.scott.fisher@gmail.com>

Sent: Tuesday, August 5, 2025 10:37 AM

To: Steven Koonin <steven.koonin@gmail.com>

Cc: roywspencer@hotmail.com; climateman60@gmail.com; ross.mckitrick@gmail.com; Judith Curry <curry.judith@gmail.com>

Subject: Re: a defense of CWG25 in the Italian press

This is so cool!

I'm hearing from Audrey Barrios that the Secretary wants to schedule us all for a call at 12:15 p.m. ET today. Is everyone able to make that happen? Sorry for the short notice, and I don't have a clue what the call is about.

Ross, could you set this up as a Google meeting?

On Tue, Aug 5, 2025 at 8:44 AM Steven Koonin <steven.koonin@gmail.com> wrote:

I also attach MS Copilot's translation to English.

I've not read the NYT "rebuttal", but the points seem awfully weak (and absent any science).

And most amusing is that the png shows Zeke's supplementary figure is now even more famous.

SEK

From: Franco Battaglia <francesco.prof.battaglia@gmail.com>

Sent: Tuesday, August 5, 2025 1:57 AM

To: Steven Koonin <steven.koonin@googlemail.com>; Steven E Koonin <steven.koonin@nyu.edu>; koonin@stanford.edu

Subject: NYT

Hi, Steve.

A few days ago the NYT wrote an article that intended to be a rebuttal of the DOE report.

Today I wrote a rebuttal of the NYT article.

It is in Italian, but AI may easily translate it into English.

Best,

franco

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From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Wednesday, August 6, 2025 4:59 PM
To: Judith Curry
Cc: Steven Koonin; Ross McKittrick; Roy Spencer; John Christy
Subject: Re: List of external reviewers

It should be: jeremy.ison@hq.doe.gov

I also have a mobile phone number for him: 832-248-5797

We talked yesterday, and I gave him the lay of the land. I think he'll do a fine job of helping you all get to a final report!

On Wed, Aug 6, 2025 at 4:54 PM Judith Curry <curry.judith@gmail.com> wrote:
Travis, do you have an email address for Jeremy Ison

On Wed, Aug 6, 2025 at 1:51 PM Travis Fisher <travis.scott.fisher@gmail.com> wrote:
Make sure this list gets to Jeremy Ison and Audrey Barrios at DOE!

On Wed, Aug 6, 2025 at 2:19 PM Steven Koonin <steven.koonin@gmail.com> wrote:
I know Matt well as a Hoover colleague. Agree that he'd be good.

Steven Koonin

On Aug 6, 2025, at 14:13, Ross McKittrick <ross.mckittrick@gmail.com> wrote:

Matthew Kahn of USC economics would also be a good choice
<https://sites.google.com/site/mek1966/>

On Wed, Aug 6, 2025 at 12:29 PM Judith Curry <curry.judith@gmail.com> wrote:
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On Tue, Aug 5, 2025 at 12:40 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

Sorry just seeing this. I'm on the road and unavailable until around 2.

On Tue, Aug 5, 2025 at 12:13 PM Travis Fisher <travis.scott.fisher@gmail.com> wrote:

Yes, look for a Google Meet link in one minute!

On Tue, Aug 5, 2025 at 12:07 PM Steven Koonin <steven.koonin@gmail.com> wrote:

I think Ross is incommunicado until later this afternoon. Is the meeting happening and, if so, how to connect?

SEK

From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Tuesday, August 5, 2025 10:37 AM
To: Steven Koonin <steven.koonin@gmail.com>
Cc: roywspencer@hotmail.com; climateman60@gmail.com; ross.mckitrick@gmail.com; Judith Curry <curry.judith@gmail.com>
Subject: Re: a defense of CWG25 in the Italian press

This is so cool!

I'm hearing from Audrey Barrios that the Secretary wants to schedule us all for a call at 12:15 p.m. ET today. Is everyone able to make that happen? Sorry for the short notice, and I don't have a clue what the call is about.

Ross, could you set this up as a Google meeting?

On Tue, Aug 5, 2025 at 8:44 AM Steven Koonin <steven.koonin@gmail.com> wrote:

I also attach MS Copilot's translation to English.

I've not read the NYT "rebuttal", but the points seem awfully weak (and absent any science).

And most amusing is that the png shows Zeke's supplementary figure is now even more famous.

SEK

From: Franco Battaglia <francesco.prof.battaglia@gmail.com>

Sent: Tuesday, August 5, 2025 1:57 AM

To: Steven Koonin <steven.koonin@googlemail.com>; Steven E Koonin <steven.koonin@nyu.edu>; koonin@stanford.edu

Subject: NYT

Hi, Steve.

A few days ago the NYT wrote an article that intended to be a rebuttal of the DOE report.

Today I wrote a rebuttal of the NYT article.

It is in Italian, but AI may easily translate it into English.

Best,

franco

--
<~WRD2301.jpg>

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curry.judith@cfanclimate.com | +1.404.803.2012
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From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Tuesday, August 5, 2025 5:26 PM
To: Steven Koonin
Cc: roywspencer@hotmail.com; climateman60@gmail.com; Judith Curry
Subject: Re: local effect of CO2

It's a wonder he has the gall to carry on like some kind of public authority. Seems to have the same delusions as Mann.

On Tue, Aug 5, 2025 at 5:23 PM Steven Koonin <steven.koonin@gmail.com> wrote:

Here's a taste of the kind of responses I expect we'll see.

Most have obvious rebuttals, but I found the first interesting – an effect I'd not heard of before. The two cited papers are attached.

As near as I can figure out, local CO2 raises temperatures slightly and so changes local water vapor and pollution dynamics, particularly ozone. A few $\times 10^{-3}$ increase in ozone-related deaths/yr, or a few hundred for the US as a whole. That compared to about 2×10^6 total deaths, so it's a 10^{-4} effect.

But the mortality estimates don't include fewer deaths due to warmer cold snaps, enhanced urban vegetation growth, people spending more time outdoors, and who knows what else is important at such low levels.

I've encouraged Jacobson to submit through the portal.

SEK

From: Mark Z Jacobson <jacobson@stanford.edu>
Sent: Tuesday, August 5, 2025 3:46 PM
Subject: Re: Report of the DOE Climate Working Group

Dear all,

This report contains inaccurate and misleading information. Here are some examples:

1. Carbon dioxide "does not affect local air quality."

Not true:

<https://web.stanford.edu/group/efmh/jacobson/Articles/V/2007GL031101.pdf>

<https://web.stanford.edu/group/efmh/jacobson/Articles/V/es903018m.pdf>

Higher temperatures are also directly responsible for longer dry seasons and drier wood, exacerbating wildfires, increasing air pollution morbidity and mortality, as discussed in many published studies.

2. The claim that CO₂ enhances photosynthesis and makes oceans less alkaline. This claim pretends as if the small impacts mentioned are far more important than CO₂'s radiative impacts on climate and air pollution and on ocean life.

3. The claim that the sun has an important role in climate change. Easily disproven simply by looking at the fact that the stratosphere is cooling far more than the troposphere is warming. If sunlight were the cause of observed global warming, the stratosphere, which absorbs UV sunlight, would warm too, but it's not. The explanation for stratospheric cooling and global warming is that CO₂ and other greenhouse gases absorb IR in the troposphere, preventing it from getting into the stratosphere, where it would otherwise be absorbed by O₃ and CO₂. It is also easy to see that solar activity has been declining, not increasing, in the past 50 years, both in terms of sunspot number and solar intensity.

4. "The global climate is naturally variable on all time scales." Misinformation. The rate of change of temperature from 1975 to 2025 has been +2.6K per 100 years, which compares with +0.052K per 100 years for the past 1000 years (based on ice core data). Even during deglaciation before the last interglacial period, the warming was only +0.13K per 100 years, or one-twentieth the rate of increase today. The rate of change of global temperature today is over an order of magnitude faster than during any natural variation.

5. "Data driven estimates of climate sensitivity." This is nothing but a "simple empirical Energy Balance Model," not a data-driven estimate. It is a model estimate with virtually the simplest of all models.

Mark

From: John Christy <climateman60@gmail.com>
Sent: Tuesday, August 5, 2025 5:42 PM
To: Ross McKittrick
Cc: Steven Koonin; roywspencer@hotmail.com; Judith Curry
Subject: Re: local effect of CO2

I suppose one could separate direct (toxic) and indirect (adds a tiny bit of warming - maybe) which may impact health, but certainly less so than the urban heat island itself. How would one separate UHI from the tiny CO2 forcing?

John C.

On Tue, Aug 5, 2025 at 4:26 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

It's a wonder he has the gall to carry on like some kind of public authority. Seems to have the same delusions as Mann.

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5. "Data driven estimates of climate sensitivity." This is nothing but a "simple empirical Energy Balance Model," not a data-driven estimate. It is a model estimate with virtually the simplest of all models.

Mark

From: Judith Curry <curry.judith@gmail.com>
Sent: Thursday, July 31, 2025 9:08 AM
To: Roy Spencer
Cc: Steven Koonin; John Christy; Ross McKittrick; Travis Fisher; Josh Loucks; Seth Cohen; andrea.woods@hq.doe.gov
Subject: Re: lots of moaning and crying about the DOE Climate Report

Decent article in science on this

<https://www.science.org/content/article/contrarian-climate-assessment-u-s-government-draws-swift-pushback>

On Thu, Jul 31, 2025 at 6:01 AM Roy Spencer <roywspencer@hotmail.com> wrote:

In the meantime, I think you all will enjoy today's blog post with some history behind all of this. Check out the graphic of us 5 "red team" researchers being surrounded by a swarm of blue team people with \$\$ raining down on them.

I made it clear the opinions stated therein are my own.

<https://www.drroyspencer.com/2025/07/some-thoughts-on-our-doe-report-regarding-co2-impacts-on-the-u-s-climate/>

From: Judith Curry <curry.judith@gmail.com>
Sent: Thursday, July 31, 2025 7:53 AM
To: Steven Koonin <steven.koonin@gmail.com>
Cc: John Christy <climateman60@gmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Josh Loucks <loucksj14@gmail.com>; Seth Cohen <seth.cohen@hq.doe.gov>; andrea.woods@hq.doe.gov <andrea.woods@hq.doe.gov>
Subject: Re: lots of moaning and crying about the DOE Climate Report

TOTALLY agree that we need the comment portal to be activated ASAP, otherwise we lose credibility

On Wed, Jul 30, 2025 at 6:46 PM Steven Koonin <steven.koonin@gmail.com> wrote:

A compilation by Willie Soon. I've not read most of them.

It's important that the comment portal be stood up as soon as possible.

Steven Koonin

Begin forwarded message:

From: Willie Soon <romeosoon@gmail.com>
Date: July 30, 2025 at 19:36:23 MDT
To: Willie Soon <romeosoon@gmail.com>
Subject: lots of moaning and crying about the DOE Climate Report

<https://www.notus.org/climate-environment/scientists-trump-climate-change-report-doe-citations-mischaracterizations>

‘A Serious Misuse of My Research’: Climate Scientists Say New Trump Energy Report Botches Their Work

“Our work has no relevance,” an astrobiologist whose research was cited in the administration’s climate change report said.

=====

<https://www.wired.com/story/scientists-say-new-government-climate-report-twists-their-work>

Scientists Say New Government Climate Report Twists Their Work

A new Department of Energy report “fundamentally misrepresents” climate research and leaves out key context, multiple scientists cited in the report tell WIRED.

=====

<https://www.eenews.net/articles/epa-attacks-climate-science-here-are-the-facts>

EPA attacks climate science. Here are the facts.

=====

<https://cen.acs.org/policy/regulation/EPA-rejects-key-finding-underpinning/103/web/2025/07>

EPA rejects key finding underpinning US climate rules

Energy secretary cites new DOE report on climate change by known climate denialists to justify repeal

=====

<https://www.politico.com/newsletters/power-switch/2025/07/30/doe-questions-climate-change-consensus-00483125>

President Donald Trump’s allies have long floated the idea of a “red team, blue team” exercise to debate the merits of climate science. On Tuesday, they got their wish.

Only the Trump administration left out the blue team.

The Department of Energy released a 141-page report on climate science this week to coincide with the administration’s plan to repeal the legal backbone of climate rules.

Written by five scientists known for denying accepted climate science, the report is rife with disinformation, write Chelsea Harvey and Scott Waldman. It uses misleading and inaccurate statements to argue that climate science has overstated the risks of a warming planet while underestimating the societal benefits of burning fossil fuels.

=====

<https://insideclimatenews.org/news/30072025/climate-scientists-fight-against-energy-department-report>

(Sorry, you have been blocked
You are unable to access insideclimatenews.org)

=====



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From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Thursday, May 1, 2025 2:14 PM
To: Judith Curry
Cc: Ross McKittrick; Roy W. Spencer; John Christy; Steven Koonin
Subject: Re: May 1 status update

I'll wait patiently until called upon to help with drafting and editing, but I have some quick updates.

My meeting slot with the Secretary yesterday morning was bumped because of briefings relevant to the cabinet meeting in the afternoon. I plan to connect with him by phone or have a more substantive meeting during our next scheduled update on the 8th.

In the meantime, his team said he would likely appreciate seeing a first draft of a cover letter or introduction for him to rewrite as needed (to be signed by him, distinct from the intro/foreword written by you all). I will take the pen on that, but please let me know if you have strong feelings about what such a cover letter should include or avoid at all costs.

On Thu, May 1, 2025 at 12:55 PM Judith Curry <curry.judith@gmail.com> wrote:

I also have an extended version of the attribution chapter, awaiting formatting and referencing. If anyone wants to take a look now, let me know and I'll send it.

On Thu, May 1, 2025 at 9:30 AM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

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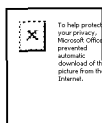
- Judy has written an overview on the topic of managing risks and I have some material to add from the econ literature.
- John can you write a section about the hot/cold extremes data that you've tabulated and charted? It provides a very clear picture that the US climate is getting less extreme and the warming is mainly in the form of fewer cold events not more heat waves.
- John can you also write a section on US precipitation, drawing on our paper and your newest data collections. I've done the regressions for the data you sent me on the US SE humid zone and I'll get those tables and charts written up. I can't remember if you sent me a new batch of Pacific data, but if you did re-send and I'll run those too.
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Ch 14 - Roy did you have something written on US vehicle emissions? I guess we're just working out the fractional contribution.

Also the document would benefit from a glossary of technical terms, acronyms etc. Roy could you make a start on that?

Cheers,
Ross

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From: Roy Spencer [roywspencer@hotmail.com]
Sent: 5/1/2025 7:43:09 PM
To: Steven Koonin [steven.koonin@gmail.com]; 'Travis Fisher' [travis.scott.fisher@gmail.com]; 'Judith Curry' [curry.judith@gmail.com]
CC: 'Ross McKittrick' [ross.mckitrick@gmail.com]; 'John Christy' [climatemanager60@gmail.com]
Subject: RE: May 1 status update

I like this. I assume the Secretary would appreciate a good draft like this to work from.
-Roy

Sent from my Verizon, Samsung Galaxy smartphone

----- Original message -----

From: Steven Koonin <steven.koonin@gmail.com>
Date: 5/1/25 2:37 PM (GMT-06:00)
To: 'Travis Fisher' <travis.scott.fisher@gmail.com>, 'Judith Curry' <curry.judith@gmail.com>
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Subject: RE: May 1 status update

Off the top of my head, here are a few points the Secretary's cover letter might make. I'm sure others can refine these or add a few more - SEK

- Good energy policy making requires a complete and accurate picture of the state of climate science
- I [Chris] have long been a student of climate science. My technical background has allowed me to read the IPCC, USG assessment reports, as well as some of the original literature, and have substantial conversations with a variety of climate scientists
- I have seen first hand how the media and political coverage imperfectly reflects, if not distorts' the state of the science, to the point where non-experts usually have it very wrong – "the science doesn't say what you think it says"
- To remedy the situation, I commissioned an independent team of credentialed experts to summarize the state of the science, with particular emphasis on the question of whether GHG emissions endanger the US population
- I have long respected scientific integrity and so have exerted no control or influence over what the team wrote – what you are reading are their own words
- ...

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To: Ross McKittrick
Cc: Travis Fisher; Roy W. Spencer; John Christy; Steven Koonin
Subject: Re: May 1 status update
Attachments: Sea level (1) .docx; heat_cold mortality (1).docx; climate sensitivity JC text.docx

Hello I've emailed last week the sea level rise and heat/cold mortality sections, I even think i put them in some folder. Here they are again, I would appreciate comments/suggestions. Also included is my version of Climate sensitivity (in case that one got lost also).

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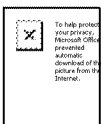
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8 Changes in Sea level

Arguably the most important climate impact driver that is unambiguously associated with increasing temperatures is global sea level rise. Global warming increases sea level rise through thermal expansion of the volume of sea water and melting of glaciers and ice sheets. Another factor that influences sea level variations is land water storage. Regional sea level change is influenced by large-scale ocean circulation patterns, and geologic processes and deformation from the redistribution of ice and water. Local sea level rise is further influenced by vertical land motion from geologic processes, ground water withdrawal, and fossil fuel extraction.

The IPCC AR6 estimates that global mean sea level increased by 7.9 (5.9–9.8) inches between 1901 and 2018. The rate of sea level rise has accelerated in recent decades. At the ocean basin scale, sea levels have risen fastest in the Western Pacific and slowest in the Eastern Pacific over the period 1993–2018.¹ The rate of global sea level rise is estimated to be 0.12 inches/year (for reference: 0.12 in is the height of two stacked pennies).²

The observing systems for global sea level rise have advanced significantly in the satellite era, particularly with the advent of satellite altimeters since 1993. Local tide gauges have provided useful data for the past century, and even longer for a few locations. Following the end of the Little Ice Age in the mid-nineteenth century, tide gauges show that the global mean sea level began rising during the period 1820–1860.

8.1 U.S. coastal sea level rise

Observed and predicted rates of mean global sea level rise may have little relevance for specific locations³. In Canada and Alaska (and also northern Washington), sea level is actually decreasing, owing to uplift from glacial rebound. Most of the Pacific coast has rates of sea level rise of 0 to 0.12 inches/year. The largest rates of sea level rise are on the Gulf coast (Louisiana and Texas) and in the mid-Atlantic states (Chesapeake Bay region).

Measurements of relative sea level rise from tide gauges conflate the rise in the volume of seawater with local vertical land motion. Hence in examining local sea level changes, it is important to also consider the local vertical land motion. Absolute local sea level rise is the sum of relative sea level rise and the local vertical land motion.

A wide range of processes can cause vertical land motion along the coasts, having amplitudes comparable to the sea level signals expected from land-ice melting or ocean thermal expansion. Vertical land motion on the coasts can locally exacerbate (subsidence/sinking) or mitigate (uplift) the risk of sea level rise. Local changes in sea level vary considerably from place to place and can

¹ B. Fox-Kemper et al., “Ocean, Cryosphere and Sea Level Change,” in *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Geneva, CH: Intergovernmental Panel on Climate Change, 2021), 1211-1362.

² “Rising Waters: How NASA Is Monitoring Sea Level Rise,” NASA (NASA), accessed May 19, 2022, <https://www.nasa.gov/specials/sea-level-rise-2020/>.

³ <https://tidesandcurrents.noaa.gov/sltrends/>

deviate substantially from the rate of global mean sea level change.⁴ Human activities triggering subsidence are soil drainage (e.g. for urban development purposes) or subsurface mining of resources such as groundwater, oil or gas. The magnitude of relative sea level rise caused by human activities is often considerable. Local vertical land motion of relevance to local sea level change is best measured using a Global Positioning System (GPS) station located in the location as the tide gauge.

Table 8.1 shows absolute sea-level rise (ASLR) for selected locations, determined from the sum of uncorrected sea-level rise as estimated from tide gauge time series (RSLR)⁵ and the vertical land motion (VLM)^{6, 7, 8} measurements. The absolute sea level rise for each of these locations is significantly smaller than the measured relative sea level rise owing to local sinking of the land. More than half of the measured relative sea level rise is attributed to land sinking for these locations: San Francisco, Galveston, Grand Isle. For reference, the global average rate of absolute sea level rise is estimated to be 0.12 inches/year.

Table 8.1 Absolute sea level rise (inches/year) (RSLR plus VLM)

Location	RSLR	VLM	ASLR
San Francisco, CA	+0.08	-0.06	+0.02
Galveston, TX	+0.26	-0.19	+0.07
Grand Isle, LA	+0.36	-0.28	+0.08
St Petersburg, FL	+0.12	-0.02	+0.10
New York City, NY	+0.11	-0.05	+0.06

San Francisco Bay

Over the past 100 years, relative sea level in the San Francisco Bay area has risen by 7.8 inches, at an average rate of 0.08 inches/year (Figure 8.1). As shown in Table 6.1, San Francisco's vertical land motion is -0.06 inches/year (sinking), producing a recent rate of absolute sea level rise of +0.02 inches/year. Portions of Treasure Island, San Francisco International Airport, and Foster City are sinking as fast as 0.4 inches/year.⁹ Landfill zones are sinking due to soil compaction, at a rate as much as one-half inch per year, threatening coastal infrastructure including the San Francisco International Airport. The problems in the San Francisco Bay area have been caused primarily by sinking in landfill regions that were formerly wetlands, not by the slow creep of global sea level rise.

⁴ Wöppelmann, G., and M. Marcos (2016), Vertical land motion as a key to understanding sea level change and variability, *Rev. Geophys.*, 54, 64–92.

⁵ NOAA Tides & Currents, Relative Sea Level Trends - <https://tidesandcurrents.noaa.gov/sltrends/>

⁶ NAS (2012) *Sea-Level Rise for the Coasts of California, Oregon and Washington: Past, Present, and Future*. Appendix A: Vertical Land Motion and Sea-Level Data Along the West Coast of the United States. National Academies Press, NAP.edu/10766.

⁷ Letetrel, C, M Karpytchev, MN Bouin et al (2015) Estimation of vertical land movement rates along the coasts of the Gulf of Mexico over the past decades. *Continental Shelf Research*, 111, 42-51.

⁸ Karegar, MA, TH Dixon, SE Engelhart (2016), Subsidence along the Atlantic Coast of North America: Insights from GPS and late Holocene relative sea level data, *Geophys. Res. Lett.*, 43, 3126–3133, doi:10.1002/2016GL068015.

⁹ Shirzaei, M, R Burgmann (2018) Global climate change and local land subsidence exacerbate inundation risk to the San Francisco Bay Area. *Science Advances*, 4, eaap9234

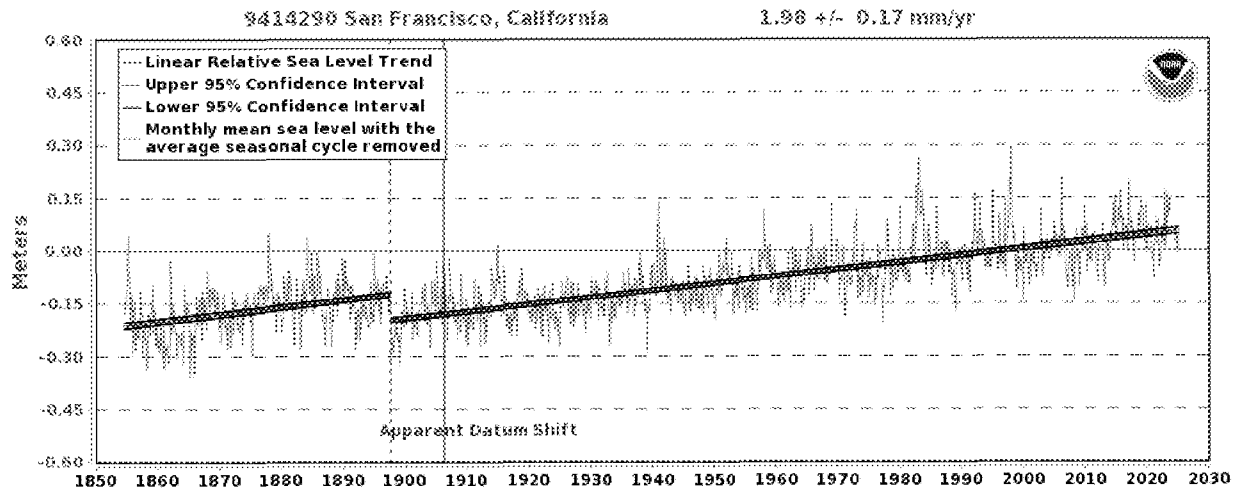


Figure 8.1. Tide gauge measurements at San Francisco, California, obtained from NOAA - https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=9414290 (downloaded 4/22/25).

Galveston - Houston

Long-term tide measurements at Galveston Pier 21 show sea level rise of 2.18 feet in the past century, or a rate of 0.26 inches/year (Figure 8.2). Vertical land motion (subsidence) at Galveston is estimated at -0.19 inches/year, yielding a value of absolute sea level rise of +0.07 inches/year (Table 8.1). The U.S. Geologic Survey found that most of the land-surface subsidence in the Houston-Galveston region has occurred as a direct result of groundwater withdrawals.¹⁰ This caused compaction of the aquifer sediments, mostly in the fine-grained silt and clay layers. By 1979, as much as 10 feet of subsidence had occurred in Houston.

Hurricanes are traditionally the major concern in the region. The 1900 hurricane that struck Galveston and killed between 6,000 and 12,000 people is still considered the United States' deadliest natural disaster.¹¹ Hurricane Ike (2008) decimated large portions of the Bolivar Peninsula literally removing significant portions of the land mass.¹² While only 17 people were killed in Texas, property damage exceeded \$50 billion.¹³ In 2017, Hurricane Harvey struck the region, bringing catastrophic rainfall-triggered flooding that inflicted over \$125 billion in damages.¹⁴

¹⁰ Kasmarek, M.C., and Ramage, J.K., 2017, Water-level altitudes 2017 and water-level changes in the Chicot, Evangeline, and Jasper aquifers and compaction 1973–2016 in the Chicot and Evangeline aquifers, Houston-Galveston region, Texas: U.S. Geological Survey Scientific Investigations Report 2017–5080, 32 p., <https://doi.org/10.3133/sir20175080>.

¹¹ Weems, John Edward, “Galveston Hurricane of 1900”, Texas State Historical Association, (March 15, 2016) <https://www.tshaonline.org/handbook/entries/galveston-hurricane-of-1900>.

¹² “Galveston County, Texas, Faces Sea Level Rise and Storms”, Union of Concerned Scientists, (June 23, 2017) <https://www.ucs.org/resources/galveston-county-texas-faces-sea-level-rise-and-storms>.

¹³ White, Audrey, “Galveston Still Healing 5 Years After Hurricane Ike”, The Texas Tribune, (April 26, 2013) <https://www.texastribune.org/2013/04/26/galveston-still-healing-5-years-after-hurricane-ike/>.

¹⁴ NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2025). <https://www.ncei.noaa.gov/access/billions/>, DOI: 10.25921/stkw-7w73

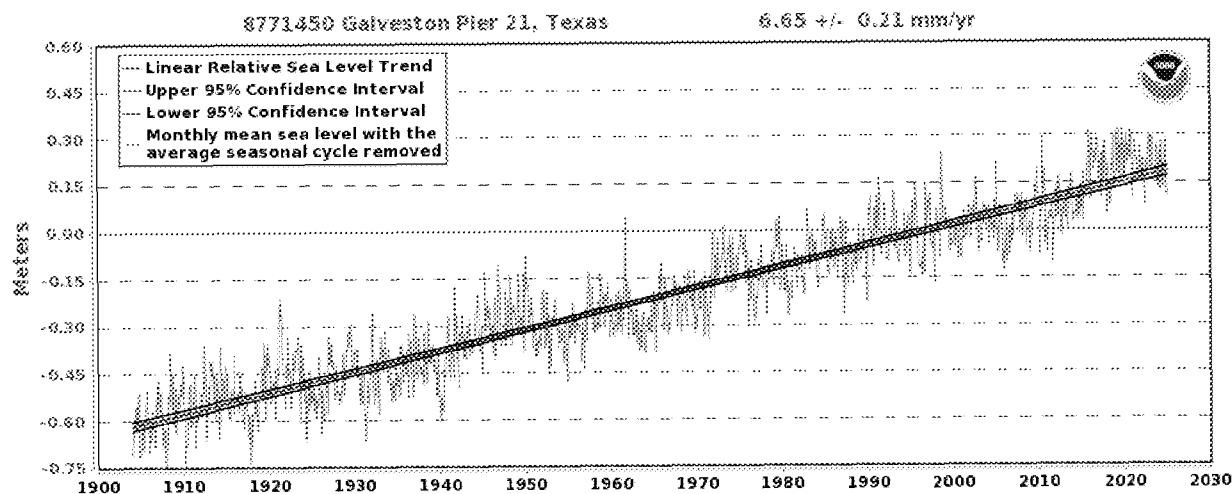


Figure 8.2. Tide gauge measurements Galveston Pier, TX, obtained from NOAA - https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8771450 (downloaded 4/22/2025).

New Orleans and the Mississippi delta

There are long-term tide gauge measurements at Grand Isle, Louisiana, respectively estimating that sea level has risen slightly more than 3 feet over the last 100 years and at an average rate of 0.36 inches/year (Figure 8.3). Vertical land motion (subsidence) is estimated -0.28 inches/year at Grand Isle. From Table 6.1, the absolute sea level rise is +0.08 inches/year at Grand Isle.

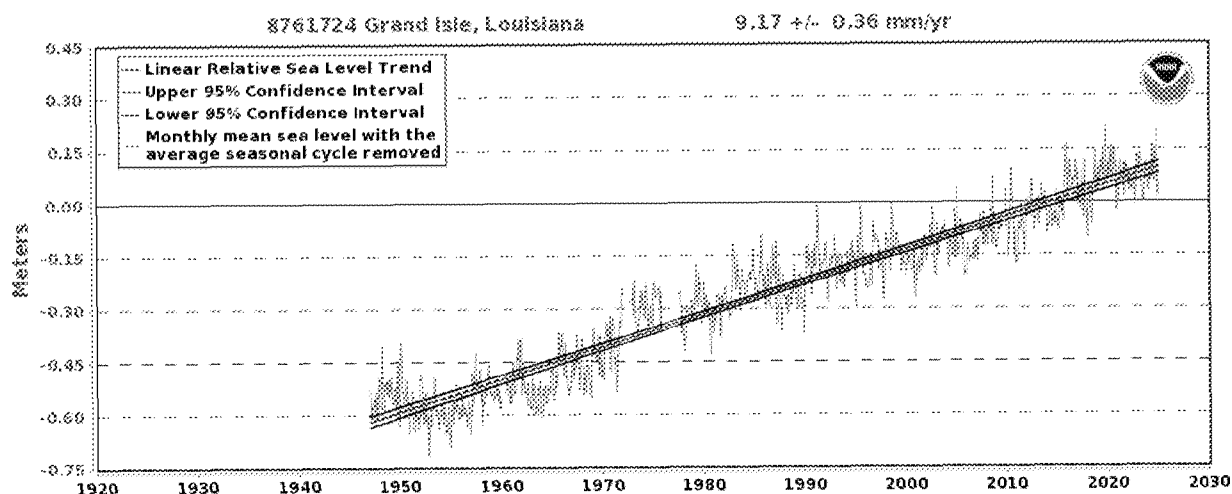


Figure 8.3. Tide gauge measurements at Grand Isle, LA, obtained from NOAA - https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8761724 (downloaded 4/22/25).

The issues of sea level rise and land loss in the Mississippi delta region are complex, with geological subsidence and the decline in sediment transported by the Mississippi river being the dominant drivers. Due to the construction of dams in the basin since the 1950s, the suspended

sediment load of the Mississippi River has decreased by ~50%.¹⁵ A new subsidence map of coastal Louisiana finds the coastal region to be sinking at about one third of an inch per year.¹⁶ For a city whose elevation averages one to two feet below sea level, sea level rise from human caused warming is not the dominant driver for the problems that New Orleans is facing.

New York City

New York City is particularly vulnerable to the effects of sea level rise because it is built primarily on islands and has 520 miles of coastline. In New York City, relative sea level has risen over 11 inches over the past century, at an average rate of 0.11 inches/year (Figure 8.4). Vertical land motion in the New York City area is occurring at a rate of -0.05 inches/year (subsidence), corresponding to roughly 5 inches per century. From Table 6.1, the absolute rate of sea level rise at The Battery location is 0.06 inches/year, or about 55% of the measured relative sea level rise.

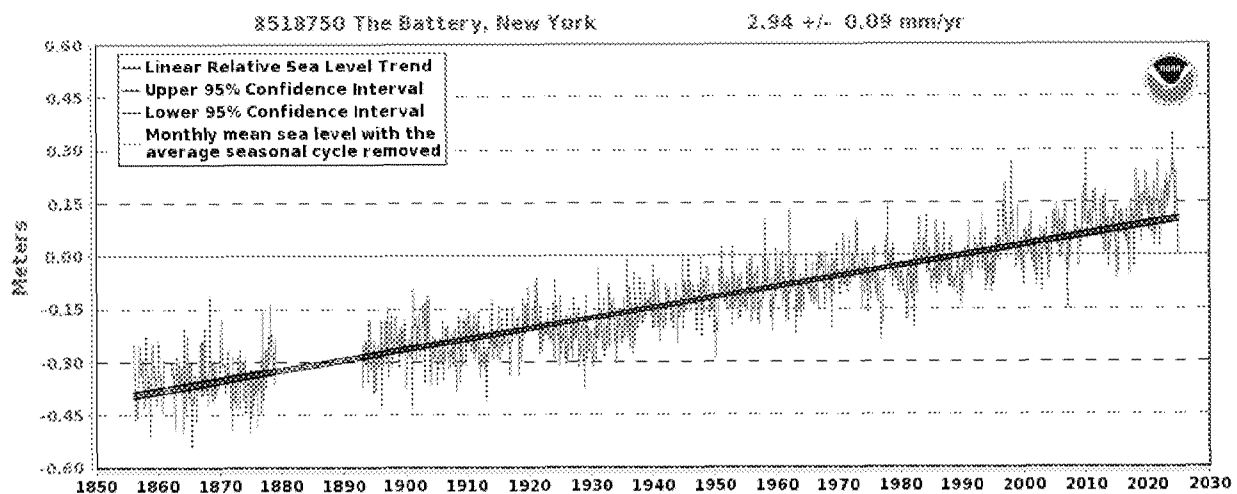


Figure 8.4. Tide gauge measurements at The Battery, New York, obtained from NOAA - https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8518750 (downloaded 4/22/25).

Following Hurricane Sandy, New York has developed a comprehensive plan: *City of New York: Building a Stronger, More Resilient New York*.¹⁷ A broad range of coastal protection measures are outlined that match the risks facing a given area: increase coastal edge elevations, minimize upland wave zones, infrastructure to protect against storm surge, improve coastal design and governance, restore estuaries wetlands, coastal nourishment, site elevation, and drainage systems.

¹⁵ Jillian M. Maloney et al., “Mississippi River Subaqueous Delta Is Entering a Stage of Retrogradation,” *Marine Geology* 400 (June 2018): 12–23, <https://doi.org/10.1016/j.margeo.2018.03.001>.

¹⁶ Jaap H. Nienhuis et al., “A New Subsidence Map for Coastal Louisiana,” *GSA Today* 27, no. 6 (June 2017): 28–29, <https://doi.org/10.1130/GSATG337GW.1>.

¹⁷ City of New York, *A Stronger, More Resilient New York* (New York: City of New York, June 2013), http://s-media.nyc.gov/agencies/sirr/SIRR_singles_Hi_res.pdf.

8.2 Sea level rise projections

The concern over sea level rise is not about the 8 inches or so that global mean sea level has risen since 1900. Rather, the concern is about projections of 21st century sea level rise based on climate model-based projections of human-caused global warming.

The IPCC AR6 finds that there is *high agreement* across published global mean sea level projections for 2050 and there is little sensitivity to emissions scenarios. Considering only projections incorporating ice-sheet processes in whose quantification there is at least *medium confidence*, the global sea level projections for 2050, across all emissions scenarios, fall between 3.94 and 15.75 inches (5th–95th percentile *very likely* range) relative to the 1995–2014 baseline period.¹⁸

Conversely, there is *low agreement* across published global mean sea level projections for 2100, particularly for higher emissions scenarios. Considering only projections representing processes in whose quantification there is at least *medium confidence*, the AR6 global mean sea level projections for 2100 lie between 7.87 and 39.37 inches (5th–95th percentile *very likely* range) under the medium emissions scenario SSP2–4.5.¹⁹ There is deep uncertainty surrounding projections of sea level rise to 2100, particularly for the higher emissions scenarios.

In evaluating the IPCC AR6 projections to 2050 (with reference to the baseline period 1995–2014), almost half of the sea level rise has already occurred by 2025. From the tide gauge measurements in Figures 8.1–8.4, there is no obvious acceleration in sea level rise beyond the historical average rate of sea level rise.

8.3 Summary

Since 1900, global sea level has risen by about 8". Sea level change along U.S. coasts is highly variable, associated with local variations in processes that contribute to sinking and also ocean circulation patterns. The highest levels of sea level rise along U.S. coasts are Galveston, New Orleans, and the Chesapeake Bay regions – each of these locations is associated with substantial local sinking that is unrelated to climate change.

Extreme projections of global sea level rise are associated with the implausible extreme emissions scenario and inclusion of poorly understood processes associated with hypothesized ice sheet instabilities. In evaluating the IPCC AR6 projections to 2050 (with reference to the baseline period 1995–2014), almost half of the sea level rise has already occurred by 2025 and at a lower rate than predicted. From the tide gauge measurements in Figures 8.1–8.4, there is no obvious acceleration in sea level rise beyond the historical average rate of sea level rise.

¹⁸ B. Fox-Kemper et al., “Ocean, Cryosphere and Sea Level Change,” in *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Geneva, CH: Intergovernmental Panel on Climate Change, 2021), 1211–1362.

¹⁹ B. Fox-Kemper et al., “Ocean, Cryosphere and Sea Level Change.”

2.3 Mortality risks from heat and cold extremes

The greatest confidence for impacts from global warming is an increase in extreme heat events and a decrease in extreme cold events; this has been observed in the historical period and is also expected with continued warming.

Mortality from heat extremes is typically caused by heat stroke and heat exhaustion. Mortality from cold extremes is typically caused by hypothermia and heart strain. It is well known that global mortality is substantially greater for extreme cold than for extreme heat.^{1,2}

Specifically with regards to the U.S., extreme heat and extreme cold both kill hundreds of people each year.; however, different approaches to assessing heat/cold mortality produces different results. The Center for Disease Control (CDC) National Center for Health Statistics Compressed Mortality Database, which is based on death certificates, indicates that about twice as many people die of “excessive cold” conditions in a given year than of “excessive heat.”^{3,4}

A 2015 epidemiological study of deaths in published in *The Lancet* found that cold-related deaths in the U.S. were about a factor of fifteen higher than heat-related deaths.⁵ However, the study did not adjust for the seasonal cycle in mortality rates, which tend to increase during the winter months due to non-weather factors like influenza.⁶ A more recent paper found that 86% of temperature-related deaths in the U.S. are due to cold-related mortality.⁷

The IPCC AR6 Working Group 2 Chapter 16.2.3.5 states how heat-related mortality is declining over time:⁸

“Heat-attributable mortality fractions have declined over time in most countries owing to general improvements in health care systems, increasing prevalence of residential air

¹ Qi Zhao et al., “Global, Regional, and National Burden of Mortality Associated with Non-Optimal Ambient Temperatures from 2000 to 2019: A Three-Stage Modelling Study,” *The Lancet Planetary Health* 5, no. 7 (July 2021), [https://doi.org/10.1016/s2542-5196\(21\)00081-4](https://doi.org/10.1016/s2542-5196(21)00081-4).

² <https://ourworldindata.org/part-one-how-many-people-die-from-extreme-temperatures-and-how-could-this-change-in-the-future>

³ Brett R. Scheffers et al., “The Broad Footprint of Climate Change from Genes to Biomes to People,” *Science* 354, no. 6313 (November 11, 2016): aaf7671, <https://doi.org/10.1126/science.aaf7671>.

⁴ Rachel H. Alinsky, Scott E. Hadland, J. Deanna Wilson, Pamela A. Matson, and Brendan Saloner, “Trends in Polysubstance Overdose Deaths Involving Opioids, Stimulants, and Benzodiazepines by Race and Ethnicity in the US, 2007-2021,” *JAMA Network Open* 7, no. 3 (March 2024): e238249, <https://doi.org/10.1001/jamanetworkopen.2024.8249>.

⁵ Lancet Commission on Climate and Health, “Health and Climate Change: Policy Responses to Protect Public Health,” *The Lancet* 386, no. 10006 (November 7, 2015): 1861–1914, [https://doi.org/10.1016/S0140-6736\(15\)60854-6](https://doi.org/10.1016/S0140-6736(15)60854-6).

⁶ Bob Henson, “Which Kills More People: Extreme Heat or Extreme Cold?” *Weather Underground*, January 22, 2019, <https://www.wunderground.com/cat6/Which-Kills-More-People-Extreme-Heat-or-Extreme-Cold>.

⁷ Tarik Benmarhnia et al., “Deaths Attributable to Heat and Cold: Comparison of Data Sources and Evaluation of Inconsistencies,” *GeoHealth* 8, no. 3 (March 2024): e2023GH000799, <https://doi.org/10.1029/2023GH000799>.

⁸ B. O'Neill et al., “Key Risks Across Sectors and Regions,” in *Climate Change 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Geneva, CH: Intergovernmental Panel on Climate Change, 2021), 2411–2538.

conditioning, and behavioral changes. These factors, which determine the susceptibility of the population to heat, have predominated over the influence of temperature change.”

A 2011 study of 40 major US cities between 1975 and 2004, found that heat wave mortality had decreased, in spite of rising temperatures, due to adaptation.⁹

By reducing mortality from cold events and adapting to heat extremes, rising temperatures are associated with a net saving of lives.

⁹ Keith T. Ingram, Carolyn W. Furman, and John W. Jones, “Climate Change Impact and Adaptation Assessment: A Guide for Coastal Resources Managers,” *Weather, Climate, and Society* 3, no. 4 (October 2011): 234–249, <https://doi.org/10.1175/WCAS-D-11-00055.1>.

4 Climate Sensitivity to CO₂ Emissions

Atmospheric CO₂ concentration has increased from its pre-industrial level of 280 parts per million (ppm) to around 425 ppm in 2021.²⁶ Human-caused warming depends not only on the amount of increasing greenhouse gases, but also on how sensitive the climate is to this increase.

Equilibrium Climate Sensitivity (ECS) is defined as the global surface warming that occurs when the concentration of CO₂ in the atmosphere is doubled, relative to pre-industrial levels.²⁷ The magnitude of the sensitivity of Earth's climate to increasing concentrations of CO₂ is at the heart of the scientific debate on anthropogenic climate change, and also the public debate on the appropriate policy response to increasing CO₂ in the atmosphere.

The magnitude of the Equilibrium Climate Sensitivity is associated with substantial uncertainties, which are highly consequential for policy making. If climate sensitivity to CO₂ concentration is low, then the impacts of increased emissions are expected to be relatively benign, and the benefits of emissions reductions much reduced. If the sensitivity is high, then even moderate increases of CO₂ could produce significant impacts. Climate sensitivity and estimates of its uncertainty are key inputs into the economic models that drive cost-benefit analyses and estimates of the social cost of carbon.

Since the 1979 Charney Report,²⁸ estimates in international assessment reports have put ECS between 1.5 and 4.5°C of warming for a doubling of CO₂ relative to pre-industrial levels. The ECS range between 1.5 and 4.5°C is characterized by the IPCC AR5 as the *likely* range (66 percent probability); the AR5 stated that ECS is *extremely unlikely* (95 percent probability) to be below 1.0°C and *very unlikely* (90 percent probability) to exceed 6.5°C.²⁹

This range of ECS values has remained stubbornly wide, despite many individual studies claiming to narrow it. Most recently, the IPCC AR6 narrowed the *likely* range of ECS to 2.5–4.0°C and the *very likely* range to be between 2.0 and 5.0°C.³⁰ This narrowing of the range on the low end is disputed.³¹

Understanding of the uncertainties is illuminated by examining the different methods of estimating climate sensitivity and the confounding effects of feedback processes.

4.1 Different Ways of Estimating Equilibrium Climate Sensitivity

Climate scientists use multiple lines of evidence to determine the Equilibrium Climate Sensitivity:

- Climate model simulations
- Historical observations
- Paleoclimatic observations
- Process understanding of feedbacks

By itself, the equilibrium warming effect of a doubling of atmospheric CO₂ is

slightly more than 1°C.³³ The large values of ECS arise from positive feedbacks that amplify the warming effect of CO₂. Water vapor feedback is positive: a warmer atmosphere may have more water vapor, which itself is a powerful greenhouse gas. Water vapor feedback is partially canceled by the fact that atmospheric temperature decreases more slowly with height above the Earth's surface when atmospheric water vapor increases. Warmer temperatures also result in less snow and sea ice cover, allowing the Earth to absorb more of the sun's radiation. Some simple estimates of these three feedbacks increase the ECS to around 2°C.³⁴

Higher values of ECS arise primarily from positive cloud feedbacks. The magnitude, and even the sign, of cloud feedbacks is the greatest source of uncertainty. Elements of cloud feedback include changes in the latitudinal distribution of clouds, changes in the distribution of cloud height (changes in low versus high clouds), changes to the phase of clouds (ice versus liquid), changes in cloud particle size (associated with changes in concentration and/or composition of aerosol particles), changes in the precipitation efficiency of clouds, and even changes in how clouds are distributed over the daily solar cycle.³⁵ It is difficult for climate models to simulate any of these cloud processes correctly owing to their small scale, let alone predict how they will change in the future. Further, cloud processes modulate the magnitudes of the water vapor, lapse rate, and the surface albedo feedbacks.³⁶

4.2.1 Climate model estimates of ECS

ECS can be determined from climate model simulations by doubling the concentration of CO₂, allowing several centuries for the warming to equilibrate. To avoid the necessity of long simulations, effective climate sensitivity is commonly evaluated from a 150-year simulation in response to a sudden quadrupling of CO₂. The spread of ECS values from the CMIP5 climate models (used in the AR5) was 2.0–4.7°C; the spread has increased for the CMIP6 models (used in the AR6) to between 1.8 and 5.7°C.^{37,38} Far from the science being settled in relation to the response of the climate system to increasing greenhouse gas concentrations, insofar as it is represented by climate models, uncertainties appear to be growing. The main cause of the overall upward shift in ECS in CMIP6 relative to CMIP5 is a larger positive cloud feedback, driven by changes to the cloud parameterizations in many CMIP6 models.³⁹

Climate sensitivity represents an emergent property of climate models—that is, it is not directly parameterized or tuned. However, collections of parameterizations are often chosen to produce an expected value of climate sensitivity, particularly with regards to sub-grid-scale cloud processes. Otherwise plausible models and parameter selections have been discarded because of perceived conflict with this warming rate, or aversion to a model's climate sensitivity being outside an accepted range. For example, Mauritsen and Roeckner (2020) [NEED REF](#) state the following regarding their Max Planck Institute climate model, “We have documented how we tuned the MPI-ESM1.2

global climate model to match the instrumental record of warming; an endeavor which has clearly been successful. Due to the historical order of events, the choice was to do this practically by *targeting an ECS of about 3 K using cloud feedbacks*, [emphasis added] as opposed to tuning the aerosol forcing.” In other words, the modelers chose an ECS value of 3°C and then tuned the cloud parameterizations to match their intended result.

The IPCC AR4 (2007) relied almost exclusively on climate models in its assessment of ECS. The IPCC AR5 (2013) relied on both climate model determinations and determinations from the historical record, noting substantial disagreements between these two methods. Because of concerns about model tuning and the high sensitivity to cloud parameterizations, the IPCC AR6 (2021) did not rely on climate model simulations in their assessment of climate sensitivity, relying on the other three methods in its assessment.

4.2.2 Data-driven estimates of ECS

Climate sensitivity is also estimated from instrumental records of surface temperatures and ocean heat content, combined with estimates of how climate forcings (e.g., greenhouse gases, solar, volcanoes, aerosols) have changed in the past.⁴⁰ Using this information, an energy budget method is used to deduce the ECS.

The accuracy of the data-driven methods depends on the quality of the input data. Assumptions are needed about ocean heat storage, and the ocean data is inadequate. The greatest source of uncertainty is the amount and composition of aerosol particles and their interactions with cloud radiative properties (the so-called aerosol indirect effect).

Since 2012 many studies have appeared in the literature tackling these various uncertainties. A recurring theme is that ECS estimates based on historical data turn out to be smaller than ECS estimates inferred from climate models (Sherwood and Forest 2024).

Paleoclimate proxies are used to evaluate the sensitivity of past climates, by comparing paleoclimate changes in the Earth’s temperatures to estimates of changes in forcings. The two most informative periods are the last glacial maximum (around 20,000 years ago), which was about 3–7°C colder than today, and a mid-Pliocene period (roughly three million years ago), which was 1–3°C warmer than today.⁴¹ The limits on cooling during the last glacial maximum give the best single evidence that high values of climate sensitivity are unlikely. However, paleoclimate estimates are associated with very large uncertainties in the estimated temperatures and forcings. Further, estimates of climate sensitivity based on past climate states may not be representative of the current state of the climate system.

Based on a review article by Sherwood et al.(2020), the IPCC AR6 determined the range of ECS values by integrating the historical, paleoclimate and feedback approaches using a Bayesian analysis method.⁴² The IPCC AR6 narrowed the likely range of ECS to 2.5–4.0°C.⁴³ Subsequent to publication of the AR6, Lewis (2023) published an extensive critique of the methodology used in the Sherwood et al. paper to determine the ECS.⁴⁴ Key concerns raised by Lewis include errors, outdated input values, and objective versus subjective Bayesian priors in the analysis. Lewis’ analysis found that climate sensitivity is estimated to be much lower and better constrained than in the Sherwood et al. analysis – median 2.16°C (1.75–2.7°C in the 17–83 percent *likely* range), and 1.55–3.2°C in the 5–95 percent *very likely* range. Lewis’ analysis implies that climate sensitivity is considerably more likely to be below 2°C than above 2.5°C.⁴⁵ The IPCC AR6 estimated only a 5 percent probability that ECS was below 2.3°C, whereas Lewis (2022) estimated it to be over 50 percent. The most recent publications on the debate between Sherwood et al. and Lewis further defend their respective positions: Sherwood and Foster (2024) and Lewis (2025).

A recent argument, one which the IPCC AR6 emphasized, is that data-driven ECS estimates might understate the future warming response to GHGs based on a so-called “pattern effect” (Forster et al 2021). The tropical Pacific is believed to be highly influential on the overall efficiency with which the Earth’s climate radiates heat to space, but heat in some parts is more efficiently removed than from others. If there is a weakening of the west-to-east temperature gradient in the tropical Pacific, the result would be a concentration of warming in a region where heat is less efficiently removed, raising the ECS of the Earth’s climate system. Most climate models simulate that rising GHGs will weaken the east-west temperature gradient, which led the IPCC in the AR6 to conclude that data-driven ECS estimates understated the *future* ECS value.

However Seager et al. (2019) pointed out that, contrary to models, the east-west temperature gradient has been strengthening rather than weakening over time. They further argued that the mechanism predicting otherwise in climate models was based on a faulty characterization of oceanic dynamics and there is no reason to expect the gradient to weaken. A similar argument was recently made by Lee et al. (2024), who concluded that “the trajectory of the observed trend reflects the response to increasing GHG loading in the atmosphere;” in other words GHG warming should lead to a future strengthening rather than a weakening of the temperature gradient. This implies, if anything, that future ECS in a warming climate will be lower than at present.

4.2 Transient Climate Response

The Transient Climate Response (TCR) is of greater utility in providing an observational constraint on climate sensitivity. TCR is the amount of warming that would occur at the time when CO₂ doubles, having increased gradually by 1 percent each year over a period of 70 years. Relative to the ECS, observationally- determined

values of TCR avoid the problems of uncertainties in ocean heat uptake and the fuzzy boundary in defining equilibrium arising from a range of timescales for the longer-term feedback processes (e.g., ice sheets). TCR is more generally related to peak warming and better constrained by historical warming, than ECS. The IPCC AR6 judged the *very likely* range of TCR to be 1.2–2.4°C.⁴⁷ In contrast to ECS, the upper bound of the TCR is more tightly constrained. For comparison, the TCR values determined by Lewis (2023) is 1.25 to 2.0°C; showing much better agreement with the AR6 values than was seen in a comparison of the ECS values.

A related but more flexible parameter is the Transient Response to cumulative carbon Emissions, or TCRE, which relates global temperature change to the cumulative emissions. TCRE is based upon a linear relationship between global average temperature and cumulative emissions, which holds for cumulative emissions of up to 2 teratons of carbon. For a given value of TCRE, we can calculate the amount of warming expected over a future period in response to scenarios of cumulative carbon emission. The IPCC AR6 provides a *very likely* range for TCRE of 1.0–2.3°C, with a median value of 1.6°C.⁴⁸

4.3. Summary

In the past 5 years, there is a growing realization that climate models are not fit for the purpose of determining the sensitivity of the climate to increasing CO₂ (ECS), owing to the dependence of this sensitivity on poorly resolved processes related to clouds and water vapor.

Data-driven approaches using historical data and paleoclimate reconstructions are generally regarded as more reliable for determining ECS, but their reliability is diminished by data inadequacies.

The IPCC AR6 upper bound for the *likely* range of ECS is 4.0°C, lower than the AR5 value of 4.5°C. This lowering of the upper bound seems well justified by the paleoclimatic estimates of the ECS.

The IPCC AR6 lower bound for the *likely* range of ECS is 2.5°C, substantially higher than the AR5 value of 1.5°C. This raising of the lower bound of the *likely* range of ECS has received a substantial challenge from the analysis of Lewis (2022, 2025) that finds the lower bound of the likely range to be 1.75°C with a median value of 2.16°C.

Estimates of the transient climate response (TCR; TCRE) are more tightly constrained on the upper bound than the ECS.

It is our assessment that a *likely* range for ECS of 1.75 to 4.0°C has the best justification.

SEE FOOTNOTES IN CH 7 of BOOK MANY OF THESE BELOW ARENT
USED AND CAN BE DELETED

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McCoy, D. T., Po-Chedley, S.,

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From: John Christy [climateman60@gmail.com]
Sent: 7/30/2025 4:01:26 PM
To: Steven Koonin [steven.koonin@gmail.com]
CC: Judith Curry [curry.judith@gmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]; Ross McKittrick [ross.mckittrick@gmail.com]; Roy Spencer [roywspencer@hotmail.com]
Subject: Re: meanwhile on X

The Secretary wants an organized, thoughtful discussion on climate change. I don't see how we can respond to the many claims (and ad hominem) made through the mouthpieces of the environmental pressure groups. We have a chance to advance his wishes through the public comment period. If we've made a mistake, we'll acknowledge it and fix it - that's the story that should carry the day at this point.

John C.

On Wed, Jul 30, 2025 at 10:15 AM Steven Koonin <steven.koonin@gmail.com> wrote:
And please send to me.

Steven E. Koonin

On Jul 30, 2025, at 09:11, Judith Curry <curry.judith@gmail.com> wrote:

sure pls send

On Wed, Jul 30, 2025 at 7:53 AM Travis Fisher <travis.scott.fisher@gmail.com> wrote:
Separate question: do you all want me to relay articles that mention the DOE report?

Example:

<https://www.eenews.net/articles/epa-attacks-climate-science-here-are-the-facts/>

On Wed, Jul 30, 2025 at 10:26 AM Travis Fisher <travis.scott.fisher@gmail.com> wrote:
This sounds like it might need to be two different calls. I plan to set one up for 3pm today and another one tomorrow or Friday for anyone we missed.

The invitation will come from my DOE account a bit later today.

On Wed, Jul 30, 2025 at 9:55 AM Ross McKittrick <ross.mckittrick@gmail.com> wrote:
I can be available at 4:30 I think.

On Wed, Jul 30, 2025 at 4:34 AM Roy Spencer <roywspencer@hotmail.com> wrote:
3-5 pm ET is fine with me.
-Roy

From: John Christy <climateman60@gmail.com>
Sent: Tuesday, July 29, 2025 10:29 PM
To: Travis Fisher <travis.scott.fisher@gmail.com>
Cc: Steven Koonin <steven.koonin@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; Ross McKittrick

<ross.mckitrick@gmail.com>; Judith Curry <curry.judith@gmail.com>

Subject: Re: meanwhile on X

I'm available 3-5p ET

John C.

Sent from my iPhone

On Jul 29, 2025, at 10:18 PM, Travis Fisher <travis.scott.fisher@gmail.com> wrote:

I followed Ross on X and will be popping popcorn for the next few months!

As I transition out of my DOE role, I want to introduce you all to Charles Park, DOE's deputy GC for energy policy (and a nice guy), who I understand will be part of the liaison team between you all and DOE for the external peer review and final draft.

Do you all have any availability between 2pm and 5pm ET tomorrow? I'd like to do a quick video meeting to help everyone get acquainted.

PS - it looked to me like the Secretary had fun talking about this project today. Also, fun fact: when I sent him the updated draft for review, his response was "no need to review—I trust the authors." You all are a special team, and you deserve a medal. Even the Canadian.

On Tue, Jul 29, 2025 at 11:06 PM Steven Koonin <steven.koonin@gmail.com> wrote:
Embarrassing behavior by scientists.

If we're really so wrong, they should be able to conjure up many specific criticisms. Yet none are forthcoming.

Steven E. Koonin

On Jul 29, 2025, at 21:01, John Christy <climateman60@gmail.com> wrote:

Hausfather did the same on CNN.

Sent from my iPhone

On Jul 29, 2025, at 9:50 PM, Roy Spencer <roywspencer@hotmail.com> wrote:

Maybe it's a good sign that Mann and Dessler seem to be about the only scientists out of "thousands" that are willing to trash us.

-Roy

From: Ross McKittrick <ross.mckittrick@gmail.com>

Sent: Tuesday, July 29, 2025 6:48 PM

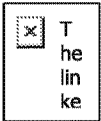
To: Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; John Christy <climateman60@gmail.com>; Steven Koonin <steven.koonin@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>

Subject: meanwhile on X

To no one's surprise Michael Mann and Andrew Dessler have dismissed the report based on the author names. Fortunately one of the Ruthless podcast hosts hasn't been blocked from Mann's feed and pointed out the problem with relying on Mann
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Judith Curry, President
CFAN - Climate Forecast Applications
Network
Reno, NV USA
curry.judith@cfanclimate.com |
+1.404.803.2012
<http://www.cfanclimate.net>



From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Tuesday, July 29, 2025 11:07 PM
To: John Christy
Cc: Roy Spencer; Judith Curry; Steven Koonin; Travis Fisher
Subject: Re: meanwhile on X

Yeah he did the same blog post gag.

The aim of the lefty media is to reassure their followers that there is no reason to read the report.

The fact that Zeke played along revealed exactly who he really is.

On Tue, Jul 29, 2025 at 11:01 PM John Christy <climateman60@gmail.com> wrote:
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Sent from my iPhone

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-Roy

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Sent: Tuesday, July 29, 2025 11:19 PM
To: Steven Koonin
Cc: John Christy; Roy Spencer; Ross McKittrick; Judith Curry
Subject: Re: meanwhile on X

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Subject: meanwhile on X

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Sent: Tuesday, July 29, 2025 11:39 PM
To: Steven Koonin
Cc: Travis Fisher; John Christy; Roy Spencer; Judith Curry
Subject: Re: meanwhile on X

Tomorrow afternoon doesn't work for me. On the road most of it. Thursday morning is better.

On Tue, Jul 29, 2025 at 11:32 PM Steven Koonin <steven.koonin@gmail.com> wrote:

If my flights are on time tomorrow I might be able to join a call from the Denver airport between 1430 and 1530 ET. Other times won't work for me.

Steven E. Koonin

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From: Roy Spencer <roywspencer@hotmail.com>
Sent: Wednesday, July 30, 2025 4:35 AM
To: John Christy; Travis Fisher
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Subject: Re: meanwhile on X

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From: Roy Spencer <roywspencer@hotmail.com>
Sent: Wednesday, July 30, 2025 12:40 PM
To: Steven Koonin; John Christy
Cc: Judith Curry; Travis Fisher; Ross McKittrick
Subject: RE: meanwhile on X

That sounds good. If she wants to use that as a quote in her article, that works, too.
-Roy

Sent from my Verizon, Samsung Galaxy smartphone

----- Original message -----

From: Steven Koonin <steven.koonin@gmail.com>
Date: 7/30/25 11:21 AM (GMT-06:00)
To: John Christy <climateman60@gmail.com>
Cc: Judith Curry <curry.judith@gmail.com>, Travis Fisher <travis.scott.fisher@gmail.com>, Ross McKittrick <ross.mckittrick@gmail.com>, Roy Spencer <roywspencer@hotmail.com>
Subject: Re: meanwhile on X

Right. Here's what I just wrote back to Maxine J at NYT:

Maxine- sound bites produced on short notice filtered through a non-expert reporter are not conducive for serious scientific communication.

If your paper will allow me an OpEd, I can respond to the questions you pose. (BTW, I note the WSJ sometimes publishes OpEds that differ dramatically from its editorial positions.)

In addition, DOE has, or soon will have, a comment portal. I and my coauthors are committed to giving serious responses to all serious criticisms.

Steven E. Koonin

On Jul 30, 2025, at 10:01, John Christy <climateman60@gmail.com> wrote:

The Secretary wants an organized, thoughtful discussion on climate change. I don't see how we can respond to the many claims (and ad hominem) made through the mouthpieces of the environmental pressure groups. We have a chance to advance his wishes through the public comment period. If we've made a mistake, we'll acknowledge it and fix it - that's the story that should carry the day at this point.

John C.

On Wed, Jul 30, 2025 at 10:15 AM Steven Koonin <steven.koonin@gmail.com> wrote:
And please send to me.

Steven E. Koonin

On Jul 30, 2025, at 09:11, Judith Curry <curry.judith@gmail.com> wrote:

sure pls send

On Wed, Jul 30, 2025 at 7:53 AM Travis Fisher <travis.scott.fisher@gmail.com> wrote:

Separate question: do you all want me to relay articles that mention the DOE report?

Example:

<https://www.eenews.net/articles/epa-attacks-climate-science-here-are-the-facts/>

On Wed, Jul 30, 2025 at 10:26 AM Travis Fisher

<travis.scott.fisher@gmail.com> wrote:

This sounds like it might need to be two different calls. I plan to set one up for 3pm today and another one tomorrow or Friday for anyone we missed.

The invitation will come from my DOE account a bit later today.

On Wed, Jul 30, 2025 at 9:55 AM Ross McKittrick

<ross.mckittrick@gmail.com> wrote:

I can be available at 4:30 I think.

On Wed, Jul 30, 2025 at 4:34 AM Roy Spencer

<roywspencer@hotmail.com> wrote:

3-5 pm ET is fine with me.

-Roy

From: John Christy <climateman60@gmail.com>

Sent: Tuesday, July 29, 2025 10:29 PM

To: Travis Fisher <travis.scott.fisher@gmail.com>

Cc: Steven Koonin <steven.koonin@gmail.com>; Roy Spencer

<roywspencer@hotmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>; Judith Curry <curry.judith@gmail.com>

Subject: Re: meanwhile on X

I'm available 3-5p ET

John C.

Sent from my iPhone

On Jul 29, 2025, at 10:18 PM, Travis Fisher
<travis.scott.fisher@gmail.com> wrote:

I followed Ross on X and will be popping popcorn for the next few months!

As I transition out of my DOE role, I want to introduce you all to Charles Park, DOE's deputy GC for energy policy (and a nice guy), who I understand will be part of the liaison team between you all and DOE for the external peer review and final draft.

Do you all have any availability between 2pm and 5pm ET tomorrow? I'd like to do a quick video meeting to help everyone get acquainted.

PS - it looked to me like the Secretary had fun talking about this project today. Also, fun fact: when I sent him the updated draft for review, his response was "no need to review—I trust the authors." You all are a special team, and you deserve a medal. Even the Canadian.

On Tue, Jul 29, 2025 at 11:06 PM Steven Koonin
<steven.koonin@gmail.com> wrote:
Embarrassing behavior by scientists.

If we're really so wrong, they should be able to conjure up many specific criticisms. Yet none are forthcoming.

Steven E. Koonin

On Jul 29, 2025, at 21:01, John Christy
<climateman60@gmail.com> wrote:

Hausfather did the same on CNN.

Sent from my iPhone

On Jul 29, 2025, at 9:50 PM,
Roy Spencer
<roywspencer@hotmail.com>
wrote:

Maybe it's a good sign that Mann and Dessler seem to be about the only scientists out of "thousands" that are willing to trash us.

-Roy

From: Ross McKittrick
<ross.mckittrick@gmail.com>
Sent: Tuesday, July 29, 2025 6:48 PM
To: Judith Curry
<curry.judith@gmail.com>; Roy W. Spencer
<roywspencer@hotmail.com>; John Christy
<climateman60@gmail.com>; Steven Koonin
<steven.koonin@gmail.com>; Travis Fisher
<travis.scott.fisher@gmail.com>
Subject: meanwhile on X

To no one's surprise Michael Mann and Andrew Dessler have dismissed the report based on the author names. Fortunately one of the Ruthless podcast hosts hasn't been blocked from Mann's feed and pointed out the problem with relying on Mann
<image.png>



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Ross McKittrick <ross.mckitrick@gmail.com>
Sent: Thursday, July 3, 2025 10:04 AM
To: Steven Koonin
Cc: Judith Curry; John Christy; Roy W. Spencer; Travis Fisher; Josh Loucks; Seth Cohen
Subject: Re: Meeting edition

From the nature paper:

Subjective attribution of extreme weather was positively associated with policy support for five widely discussed climate policies. However, exposure to most types of extreme weather event did not predict policy support. Overall, these results suggest that subjective attribution could facilitate climate policy support.

Translation: People haven't yet been bamboozled into thinking carbon taxes will prevent bad weather but with enough propaganda maybe we can change that.

On Wed, Jul 2, 2025 at 3:28 PM Steven Koonin <steven.koonin@gmail.com> wrote:
Subjective attribution = fairy tale

Steven E. Koonin

On Jul 2, 2025, at 15:17, Judith Curry <curry.judith@gmail.com> wrote:

new paper says the quiet part out loud

<https://www.nature.com/articles/s41558-025-02372-4>

On Wed, Jul 2, 2025 at 10:37 AM Steven Koonin <steven.koonin@gmail.com> wrote:
It's name plate capacity.

Typical capacity factors (actual generation vs name plate) are about 20% for solar and 33% for onshore wind, compared to 92% for nuclear and 50% for gas turbines.

Steven Koonin

On Jul 2, 2025, at 13:16, John Christy <climateman60@gmail.com> wrote:

All

In this paragraph quoted from NCA5

"Recent growth in the capacities of wind, solar, and battery storage technologies is supported by rapidly falling costs of zero- and low-carbon energy technologies, which can support even deeper emissions reductions. For example, wind and solar energy costs dropped 70% and 90%, respectively, over the last decade, while 80% of new generation capacity in 2020 came from renewable sources. "

does "new generation capacity" mean name-plate capacity or actual generation of power compared with all new generation of power in 2020?

John C.

On Tue, Jul 1, 2025 at 10:55 AM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I've taken Steve's version and done a bit of tidying to make it easier for us to go through in our Thursday meeting.

- minor edits have been accepted to remove the strikethrough wording
- Where text is currently disputed it is bracketed  before and after.
- A few minor edits of my own in green text.

Ross

--



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Ross McKittrick <ross.mckitrick@gmail.com>
Sent: Friday, June 13, 2025 9:36 AM
To: Travis Fisher
Cc: Judith Curry; Roy W. Spencer; John Christy; Steven Koonin; Josh Loucks
Subject: Re: Metadata for CWG report

Good idea. Please proceed. I'd rather do this now than people later demanding details that we ship have included.

On Fri, Jun 13, 2025 at 9:27 AM Travis Fisher <travis.scott.fisher@gmail.com> wrote:

I like your idea, Judy, as long as it's doable. Based on our conversations with the Secretary, my sense is that more transparency is better.

On Fri, Jun 13, 2025 at 9:15 AM Judith Curry <curry.judith@gmail.com> wrote:

I did a quick review of the CWG report. The self-citations will be noted, but i don't think they are overwhelming.

The issue of bigger concern is the figures and tables. I think we should add an appendix on metadata for figures and tables, outlining exactly what was done and data sources for each figure.

Without this, some of our criticisms of NCA5 will seem pretty hollow.

If you like this idea, i can put together a skeleton doc for this, with details to be filled in mostly by Ross and John



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Ross McKittrick [ross.mckittrick@gmail.com]
Sent: 5/21/2025 1:17:57 AM
To: John Christy [climateman60@gmail.com]
CC: Judith Curry [curry.judith@gmail.com]; Roy W. Spencer [roywspencer@hotmail.com]; Steve Koonin [steven.koonin@gmail.com]
Subject: Re: Model-obs comparison in troposphere
Attachments: CMIP6_20200521_Ross.xlsx

It needs to match the formatting of the attached: each model on a separate sheet, columns and rows positioned just so.

On Tue, May 20, 2025 at 9:12 PM John Christy <climateman60@gmail.com> wrote:
Ross

I can reformat if you could send what you need.

John C.

Sent from my iPhone

On May 20, 2025, at 7:37 PM, Ross McKittrick <ross.mckittrick@gmail.com> wrote:

The updated data you sent are formatted very differently from the earlier spreadsheets and would take a lot of coding to get into the program.

On Tue, May 20, 2025 at 8:35 PM John Christy <climateman60@gmail.com> wrote:
Oh, I see through 2018.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 20, 2025, at 7:04 PM, Ross McKittrick <ross.mckittrick@gmail.com> wrote:

Is this better?

<image.png>

Figure 5.4: Observed versus modeled warming trends in the global lower (LT) and mid-troposphere (MT).

Adapted from McKittrick and Christy (2020). Blue dots: warming trends ($^{\circ}\text{C}/\text{decade}$ 1979-2018) with 95% confidence interval bars for 3 data products (satellite, radiosondes and reanalysis) and 95% confidence interval bars. Blue dashed line: warming trend average for 3 observed series. Red dots: modeled warming trends in 36 models.

LT Global

	RAOBCOR	RICH17	RATPAC	UAHv6.0	RSSv4.0	Avg Sat	ERA-I	ERA5
1958	-0.400	-0.410	-0.288					
1959	-0.454	-0.466	-0.380					
1960	-0.474	-0.507	-0.392					
1961	-0.388	-0.465	-0.345					
1962	-0.473	-0.557	-0.477					
1963	-0.451	-0.540	-0.460					
1964	-0.600	-0.680	-0.709					
1965	-0.741	-0.820	-0.727					
1966	-0.511	-0.589	-0.498					
1967	-0.488	-0.563	-0.507					
1968	-0.635	-0.726	-0.572					
1969	-0.352	-0.446	-0.361					
1970	-0.324	-0.387	-0.356					
1971	-0.696	-0.747	-0.644					
1972	-0.546	-0.600	-0.470					
1973	-0.240	-0.285	-0.207					
1974	-0.599	-0.621	-0.565					
1975	-0.574	-0.586	-0.519					
1976	-0.753	-0.780	-0.704					
1977	-0.294	-0.335	-0.230					
1978	-0.337	-0.368	-0.323					
1979	-0.226	-0.250	-0.189	-0.209	-0.280	-0.244	-0.030	-0.146
1980	-0.082	-0.114	-0.060	-0.041	-0.128	-0.085	0.020	-0.065
1981	-0.099	-0.124	-0.067	-0.111	-0.143	-0.127	-0.036	-0.084
1982	-0.307	-0.334	-0.295	-0.296	-0.344	-0.320	-0.236	-0.286
1983	-0.094	-0.111	-0.140	-0.041	-0.112	-0.077	-0.028	-0.060
1984	-0.370	-0.389	-0.351	-0.237	-0.375	-0.306	-0.287	-0.321
1985	-0.322	-0.356	-0.310	-0.361	-0.430	-0.396	-0.312	-0.361
1986	-0.238	-0.285	-0.265	-0.219	-0.313	-0.266	-0.213	-0.241

1987	0.020	-0.012	-0.015	0.050	-0.017	0.016	0.047	0.020
1988	0.027	0.022	0.022	0.039	-0.048	-0.005	0.076	0.071
1989	-0.211	-0.196	-0.224	-0.209	-0.251	-0.230	-0.207	-0.150
1990	0.018	0.041	0.009	0.013	-0.075	-0.031	0.041	0.103
1991	0.025	0.037	-0.030	0.021	-0.029	-0.004	0.026	0.079
1992	-0.314	-0.314	-0.293	-0.280	-0.302	-0.291	-0.298	-0.203
1993	-0.214	-0.227	-0.224	-0.202	-0.238	-0.220	-0.267	-0.178
1994	-0.110	-0.139	-0.070	-0.064	-0.102	-0.083	-0.144	-0.088
1995	-0.021	-0.040	0.028	0.070	0.038	0.054	-0.029	0.032
1996	-0.116	-0.135	-0.153	-0.009	-0.062	-0.036	-0.126	-0.080
1997	-0.079	-0.110	-0.100	-0.007	-0.026	-0.016	-0.105	-0.066
1998	0.458	0.458	0.377	0.484	0.440	0.462	0.346	0.371
1999	-0.029	-0.026	-0.075	-0.017	-0.026	-0.021	-0.119	-0.102
2000	-0.073	-0.072	-0.105	-0.020	-0.032	-0.026	-0.094	-0.128
2001	0.096	0.087	0.094	0.115	0.137	0.126	0.096	0.050
2002	0.218	0.208	0.192	0.217	0.247	0.232	0.195	0.193
2003	0.208	0.203	0.244	0.187	0.263	0.225	0.218	0.187
2004	0.137	0.136	0.143	0.080	0.188	0.134	0.131	0.095
2005	0.313	0.327	0.355	0.199	0.323	0.261	0.331	0.247
2006	0.195	0.223	0.283	0.114	0.235	0.175	0.274	0.173
2007	0.246	0.282	0.266	0.160	0.273	0.216	0.235	0.200
2008	-0.062	-0.018	0.021	-0.101	0.065	-0.018	-0.042	-0.043
2009	0.164	0.213	0.228	0.094	0.235	0.165	0.150	0.160
2010	0.374	0.419	0.454	0.331	0.482	0.407	0.375	0.411
2011	0.064	0.108	0.182	0.016	0.155	0.085	0.076	0.109
2012	0.144	0.190	0.238	0.053	0.211	0.132	0.105	0.151
2013	0.274	0.320	0.357	0.137	0.280	0.209	0.217	0.248
2014	0.307	0.352	0.383	0.182	0.334	0.258	0.251	0.287
2015	0.436	0.475	0.524	0.275	0.459	0.367	0.362	0.401
2016	0.745	0.783	0.766	0.526	0.648	0.587	0.636	0.662
2017	0.546	0.585	0.598	0.403	0.529	0.466	0.452	0.536
2018	0.429	0.468	0.466	0.226	0.389	0.307	0.301	0.413
2019	0.649568	0.687508	0.683475	0.441	0.593467	0.517234		0.612485
79-19	0.187	0.208	0.208	0.132	0.208	0.170	0.142	0.168
95-19	0.227	0.258	0.272	0.109	0.202	0.156	0.186	0.225

					LT Tropics		
JRA	MERRA	Sonde Ave	Sat Avg	Reanal Avg	RAOBCOR RICH		
-0.236		-0.366		-0.236	1958	-0.045	-0.138
-0.354		-0.434		-0.354	1959	-0.317	-0.438
-0.406		-0.458		-0.406	1960	-0.380	-0.492
-0.416		-0.399		-0.416	1961	-0.572	-0.673
-0.493		-0.502		-0.493	1962	-0.529	-0.645
-0.465		-0.484		-0.465	1963	-0.469	-0.595
-0.608		-0.663		-0.608	1964	-0.610	-0.725
-0.660		-0.763		-0.660	1965	-0.780	-0.891
-0.427		-0.533		-0.427	1966	-0.424	-0.516
-0.529		-0.520		-0.529	1967	-0.631	-0.716
-0.574		-0.644		-0.574	1968	-0.620	-0.777
-0.260		-0.386		-0.260	1969	-0.036	-0.192
-0.333		-0.356		-0.333	1970	-0.058	-0.101
-0.641		-0.696		-0.641	1971	-1.015	-1.046
-0.415		-0.539		-0.415	1972	-0.420	-0.482
-0.191		-0.244		-0.191	1973	-0.182	-0.254
-0.611		-0.595		-0.611	1974	-0.804	-0.843
-0.534		-0.560		-0.534	1975	-0.765	-0.800
-0.641		-0.746		-0.641	1976	-0.747	-0.832
-0.233		-0.286		-0.233	1977	-0.214	-0.316
-0.290		-0.343		-0.290	1978	-0.231	-0.291
-0.142		-0.222	-0.244	-0.106	1979	-0.118	-0.174
-0.073	-0.051	-0.086	-0.085	-0.042	1980	0.019	-0.042
-0.127	-0.123	-0.097	-0.127	-0.092	1981	-0.150	-0.221
-0.261	-0.315	-0.312	-0.320	-0.275	1982	-0.214	-0.278
-0.050	-0.108	-0.115	-0.077	-0.061	1983	0.109	0.080
-0.351	-0.382	-0.370	-0.306	-0.335	1984	-0.407	-0.416
-0.357	-0.410	-0.329	-0.396	-0.360	1985	-0.396	-0.420
-0.239	-0.315	-0.263	-0.266	-0.252	1986	-0.222	-0.279

0.071	-0.006	-0.002	0.016	0.033	1987	0.255	0.207
0.022	0.038	0.024	-0.005	0.052	1988	-0.011	-0.031
-0.232	-0.222	-0.210	-0.230	-0.203	1989	-0.428	-0.428
0.013	0.012	0.023	-0.031	0.042	1990	-0.031	-0.032
-0.024	-0.023	0.010	-0.004	0.015	1991	0.039	0.028
-0.258	-0.235	-0.307	-0.291	-0.248	1992	-0.128	-0.154
-0.201	-0.175	-0.221	-0.220	-0.205	1993	-0.114	-0.147
-0.070	-0.047	-0.106	-0.083	-0.087	1994	-0.083	-0.132
0.019	0.026	-0.011	0.054	0.012	1995	0.071	0.060
-0.102	-0.091	-0.135	-0.036	-0.100	1996	-0.110	-0.130
-0.041	-0.021	-0.096	-0.016	-0.058	1997	-0.001	-0.054
0.450	0.457	0.431	0.462	0.406	1998	0.528	0.522
-0.057	-0.059	-0.043	-0.021	-0.084	1999	-0.314	-0.301
-0.074	-0.064	-0.083	-0.026	-0.090	2000	-0.189	-0.188
0.093	0.125	0.092	0.126	0.091	2001	0.021	0.002
0.205	0.252	0.206	0.232	0.211	2002	0.244	0.220
0.210	0.283	0.219	0.225	0.224	2003	0.257	0.233
0.123	0.214	0.139	0.134	0.141	2004	0.166	0.155
0.259	0.327	0.332	0.261	0.291	2005	0.352	0.387
0.206	0.210	0.234	0.175	0.216	2006	0.171	0.234
0.191	0.197	0.264	0.216	0.206	2007	0.141	0.213
-0.036	-0.027	-0.019	-0.018	-0.037	2008	-0.211	-0.132
0.189	0.147	0.202	0.165	0.161	2009	0.232	0.319
0.429	0.334	0.415	0.407	0.387	2010	0.405	0.500
0.088	0.022	0.118	0.085	0.074	2011	-0.132	-0.038
0.135	0.078	0.191	0.132	0.117	2012	0.064	0.143
0.253	0.175	0.317	0.209	0.223	2013	0.228	0.318
0.294	0.235	0.347	0.258	0.267	2014	0.278	0.351
0.441	0.374	0.479	0.367	0.395	2015	0.488	0.546
0.657	0.546	0.765	0.587	0.625	2016	0.763	0.815
0.420	0.459	0.577	0.466	0.467	2017	0.451	0.493
0.265	0.328	0.454	0.307	0.327	2018	0.247	0.301
0.471123	0.5691	0.674	0.517	0.551	2019		
0.163	0.170	0.201	0.170	0.161		0.144	0.182
0.178	0.157	0.252	0.156	0.190			

RATPAC	UAH	RSS4.0	ERA-I	ERA5	JRA-55	MERRA-2	Sonde Ave	Sat Avg
0.073					-0.153		-0.037	
-0.316					-0.377		-0.357	
-0.316					-0.415		-0.396	
-0.535					-0.573		-0.593	
-0.458					-0.555		-0.544	
-0.403					-0.479		-0.489	
-0.542					-0.628		-0.625	
-0.711					-0.649		-0.794	
-0.299					-0.377		-0.413	
-0.555					-0.618		-0.634	
-0.462					-0.546		-0.620	
-0.093					-0.064		-0.107	
-0.226					-0.260		-0.128	
-0.833					-0.825		-0.965	
-0.397					-0.300		-0.433	
-0.134					-0.167		-0.190	
-0.693					-0.741		-0.780	
-0.710					-0.717		-0.758	
-0.747					-0.650		-0.775	
-0.263					-0.216		-0.264	
-0.249					-0.271		-0.257	
-0.079	-0.229	-0.114	0.135	-0.008	-0.040		-0.124	-0.171
0.014	-0.098	-0.031	0.086	-0.006	-0.011	-0.026	-0.003	-0.065
-0.099	-0.229	-0.199	-0.091	-0.174	-0.157	-0.189	-0.157	-0.214
-0.195	-0.242	-0.225	-0.114	-0.197	-0.165	-0.254	-0.229	-0.234
0.118	0.159	0.135	0.203	0.144	0.148	0.046	0.102	0.147
-0.364	-0.312	-0.386	-0.340	-0.384	-0.371	-0.440	-0.396	-0.349
-0.383	-0.455	-0.507	-0.384	-0.435	-0.424	-0.522	-0.400	-0.481
-0.278	-0.216	-0.284	-0.204	-0.234	-0.231	-0.371	-0.260	-0.250

0.276	0.309	0.248	0.295	0.277	0.270	0.136	0.246	0.279
0.003	-0.003	-0.061	0.031	0.033	-0.008	0.008	-0.013	-0.032
-0.451	-0.424	-0.443	-0.411	-0.334	-0.396	-0.360	-0.435	-0.433
-0.017	-0.061	-0.102	-0.002	0.057	-0.025	-0.012	-0.027	-0.081
-0.011	0.006	-0.017	0.024	0.062	0.004	0.024	0.019	-0.006
-0.108	-0.177	-0.167	-0.169	-0.090	-0.147	-0.061	-0.130	-0.172
-0.123	-0.115	-0.116	-0.120	-0.046	-0.115	-0.040	-0.128	-0.116
-0.068	-0.037	-0.077	-0.103	-0.047	-0.069	0.003	-0.095	-0.057
0.093	0.135	0.076	0.075	0.110	0.059	0.099	0.075	0.105
-0.171	-0.023	-0.079	-0.115	-0.070	-0.114	-0.066	-0.137	-0.051
-0.072	0.109	0.075	0.042	0.076	0.054	0.126	-0.042	0.092
0.504	0.679	0.588	0.515	0.581	0.581	0.640	0.518	0.633
-0.353	-0.254	-0.282	-0.373	-0.319	-0.269	-0.269	-0.323	-0.268
-0.267	-0.150	-0.187	-0.230	-0.253	-0.192	-0.183	-0.215	-0.168
-0.039	0.025	0.002	-0.028	-0.074	-0.017	0.010	-0.006	0.014
0.197	0.209	0.221	0.148	0.155	0.206	0.245	0.220	0.215
0.249	0.239	0.268	0.217	0.203	0.237	0.299	0.246	0.254
0.206	0.099	0.176	0.116	0.079	0.117	0.212	0.176	0.137
0.377	0.278	0.355	0.318	0.246	0.310	0.382	0.372	0.317
0.238	0.085	0.174	0.182	0.098	0.156	0.155	0.215	0.130
0.188	0.108	0.196	0.125	0.103	0.114	0.118	0.181	0.152
-0.191	-0.254	-0.120	-0.199	-0.191	-0.186	-0.191	-0.178	-0.187
0.219	0.159	0.287	0.207	0.209	0.218	0.148	0.257	0.223
0.524	0.352	0.452	0.381	0.415	0.414	0.305	0.476	0.402
-0.015	-0.142	-0.024	-0.090	-0.080	-0.054	-0.140	-0.062	-0.083
0.087	-0.053	0.078	0.003	0.021	0.045	-0.031	0.098	0.013
0.258	0.099	0.247	0.189	0.200	0.208	0.116	0.268	0.173
0.259	0.146	0.290	0.219	0.237	0.249	0.176	0.296	0.218
0.502	0.353	0.529	0.438	0.472	0.464	0.391	0.512	0.441
0.797	0.628	0.771	0.702	0.724	0.723	0.599	0.792	0.700
0.456	0.333	0.460	0.359	0.447	0.344	0.365	0.466	0.396
0.284	0.141	0.293	0.157	0.278	0.180	0.210	0.277	0.217
0.613	0.473	0.650		0.602	0.492	0.562	0.613	0.561

0.160	0.125	0.175	0.105	0.136	0.136	0.145	0.167	0.150
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MT GL						
		RAOBCOR RICH	RATPAC A UNSW		UAH	
Reanal Avg	1955					
	1956					
	1957					
	1958	-0.162	-0.204	-0.116		
	1959	-0.244	-0.279	-0.203	-0.138	
	1960	-0.255	-0.284	-0.218	-0.214	
	1961	-0.254	-0.291	-0.188	-0.223	
	1962	-0.337	-0.391	-0.322	-0.331	
	1963	-0.209	-0.256	-0.196	-0.257	
	1964	-0.285	-0.325	-0.368	-0.307	
	1965	-0.576	-0.621	-0.523	-0.402	
	1966	-0.306	-0.351	-0.272	-0.247	
	1967	-0.347	-0.382	-0.322	-0.339	
	1968	-0.453	-0.501	-0.397	-0.434	
	1969	-0.201	-0.256	-0.158	-0.195	
	1970	-0.134	-0.149	-0.183	-0.203	
	1971	-0.558	-0.563	-0.476	-0.415	
	1972	-0.454	-0.482	-0.310	-0.343	
	1973	-0.092	-0.138	-0.070	-0.054	
	1974	-0.492	-0.497	-0.421	-0.340	
	1975	-0.407	-0.413	-0.354	-0.237	
	1976	-0.629	-0.657	-0.524	-0.445	
	1977	-0.182	-0.233	-0.066	-0.095	
	1978	-0.215	-0.252	-0.168	-0.175	
0.029	1979	-0.119	-0.149	-0.022	-0.112	-0.110
0.011	1980	0.018	-0.025	0.075	0.022	0.040
-0.153	1981	-0.051	-0.093	0.000	-0.070	-0.051
-0.183	1982	-0.142	-0.167	-0.072	-0.092	-0.128
0.135	1983	0.023	0.011	0.033	0.063	0.069
-0.384	1984	-0.322	-0.344	-0.256	-0.196	-0.250
-0.441	1985	-0.324	-0.357	-0.253	-0.241	-0.299
-0.260	1986	-0.213	-0.254	-0.198	-0.193	-0.209

0.244	1987	0.102	0.061	0.123	0.092	0.093
0.016	1988	0.087	0.084	0.086	0.063	0.066
-0.375	1989	-0.170	-0.142	-0.173	-0.128	-0.188
0.004	1990	0.084	0.119	0.075	0.109	0.029
0.028	1991	0.138	0.164	0.096	0.117	0.095
-0.117	1992	-0.123	-0.119	-0.131	-0.097	-0.119
-0.080	1993	-0.205	-0.212	-0.231	-0.140	-0.197
-0.054	1994	-0.090	-0.118	-0.094	-0.075	-0.080
0.086	1995	-0.050	-0.070	-0.082	-0.065	0.000
-0.091	1996	-0.152	-0.178	-0.197	-0.191	-0.060
0.075	1997	-0.108	-0.146	-0.137	-0.118	-0.022
0.579	1998	0.425	0.410	0.338	0.367	0.425
-0.307	1999	-0.073	-0.077	-0.152	-0.096	-0.080
-0.214	2000	-0.144	-0.153	-0.179	-0.165	-0.103
-0.027	2001	0.051	0.023	0.030	-0.001	0.064
0.189	2002	0.191	0.166	0.181	0.093	0.195
0.239	2003	0.156	0.135	0.178	0.125	0.149
0.131	2004	0.102	0.088	0.095	0.034	0.062
0.314	2005	0.229	0.246	0.242	0.140	0.150
0.148	2006	0.121	0.156	0.167	0.087	0.058
0.115	2007	0.141	0.190	0.143	0.171	0.097
-0.192	2008	-0.143	-0.092	-0.112	-0.084	-0.154
0.195	2009	0.077	0.132	0.111	0.089	0.067
0.379	2010	0.337	0.394	0.373	0.403	0.321
-0.091	2011	-0.005	0.049	0.038	0.085	-0.027
0.009	2012	0.075	0.123	0.108	0.095	0.040
0.178	2013	0.243	0.299	0.255	0.249	0.153
0.220	2014	0.217	0.268	0.234	0.256	0.160
0.441	2015	0.359	0.402	0.394	0.403	0.246
0.687	2016	0.606	0.647	0.576		0.455
0.379	2017	0.432	0.463	0.408		0.317
0.206	2018	0.298	0.335	0.288		0.165
0.552						

0.130	#DIV/0!	0.120	0.143	0.112	0.092	0.090
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							MT Tropics
RSS	ERA5	JRA55	MERRA2	Sonde Ave	Sat Avg	Reanal Avg	
							1955
							1956
							1957
		-0.097		-0.161			1958
		-0.205		-0.216			1959
		-0.283		-0.243			1960
		-0.268		-0.239			1961
		-0.387		-0.345			1962
		-0.283		-0.229			1963
		-0.385		-0.321			1964
		-0.540		-0.530			1965
		-0.292		-0.294			1966
		-0.408		-0.347			1967
		-0.465		-0.446			1968
		-0.169		-0.202			1969
		-0.242		-0.167			1970
		-0.521		-0.503			1971
		-0.368		-0.397			1972
		-0.125		-0.089			1973
		-0.523		-0.438			1974
		-0.407		-0.353			1975
		-0.564		-0.564			1976
		-0.167		-0.144			1977
		-0.216		-0.202			1978
-0.172	0.017	-0.093		-0.100	-0.141	-0.038	1979
-0.008	0.078	0.023	-0.004	0.022	0.016	0.032	1980
-0.101	-0.023	-0.074	-0.117	-0.054	-0.076	-0.071	1981
-0.174	-0.093	-0.151	-0.207	-0.118	-0.151	-0.151	1982
0.029	0.081	0.012	-0.038	0.033	0.049	0.018	1983
-0.300	-0.271	-0.299	-0.379	-0.279	-0.275	-0.316	1984
-0.345	-0.327	-0.321	-0.425	-0.294	-0.322	-0.357	1985
-0.270	-0.180	-0.199	-0.304	-0.214	-0.240	-0.228	1986

0.030	0.152	0.079	0.020	0.094	0.062	0.084	1987
-0.001	0.131	0.077	0.068	0.080	0.032	0.092	1988
-0.260	-0.122	-0.177	-0.209	-0.154	-0.224	-0.169	1989
-0.033	0.143	0.057	0.055	0.097	-0.002	0.085	1990
0.042	0.198	0.083	0.048	0.129	0.068	0.110	1991
-0.146	-0.014	-0.127	-0.111	-0.118	-0.133	-0.084	1992
-0.222	-0.147	-0.194	-0.158	-0.197	-0.210	-0.167	1993
-0.097	-0.088	-0.074	-0.066	-0.094	-0.088	-0.076	1994
-0.024	-0.050	-0.008	-0.011	-0.067	-0.012	-0.023	1995
-0.075	-0.148	-0.094	-0.116	-0.179	-0.068	-0.119	1996
-0.029	-0.103	-0.058	-0.037	-0.127	-0.026	-0.066	1997
0.430	0.352	0.395	0.443	0.385	0.428	0.396	1998
-0.044	-0.165	-0.100	-0.107	-0.100	-0.062	-0.124	1999
-0.060	-0.272	-0.126	-0.119	-0.160	-0.081	-0.172	2000
0.124	-0.086	0.033	0.081	0.026	0.094	0.009	2001
0.269	0.148	0.190	0.220	0.158	0.232	0.186	2002
0.226	0.097	0.159	0.245	0.148	0.188	0.167	2003
0.128	0.054	0.090	0.184	0.080	0.095	0.109	2004
0.218	0.124	0.219	0.286	0.214	0.184	0.210	2005
0.125	0.089	0.129	0.176	0.133	0.091	0.131	2006
0.156	0.140	0.129	0.178	0.161	0.127	0.149	2007
-0.090	-0.130	-0.112	-0.071	-0.108	-0.122	-0.104	2008
0.124	0.118	0.094	0.121	0.102	0.095	0.111	2009
0.370	0.395	0.366	0.351	0.377	0.345	0.371	2010
0.030	0.002	0.020	0.005	0.042	0.001	0.009	2011
0.099	0.064	0.084	0.046	0.100	0.070	0.065	2012
0.220	0.228	0.208	0.183	0.262	0.187	0.206	2013
0.234	0.245	0.222	0.222	0.244	0.197	0.230	2014
0.328	0.363	0.328	0.361	0.389	0.287	0.351	2015
0.541	0.589	0.562	0.520	0.610	0.498	0.557	2016
0.400	0.448	0.389	0.398	0.434	0.359	0.412	2017
0.244	0.288	0.234	0.263	0.307	0.204	0.262	2018
							2019
0.135	0.099	0.116	0.140	0.123	0.112	0.116	

RAOB AVC	RAOBCOR	RICH	RATPAC A	UNSW	UAH	RSS	NOAA	UW
-0.262	-0.202	0.093	0.107					
-0.289	-0.220	-0.069	-0.216	-0.310				
-0.276	-0.214	-0.209	-0.259	-0.383				
-0.391	-0.349	-0.332	-0.368	-0.366				
-0.436	-0.387	-0.389	-0.349	-0.415				
-0.294	-0.240	-0.227	-0.320	-0.298				
-0.421	-0.369	-0.356	-0.319	-0.367				
-0.700	-0.653	-0.648	-0.560	-0.402				
-0.338	-0.297	-0.290	-0.143	-0.207				
-0.506	-0.477	-0.456	-0.354	-0.400				
-0.576	-0.518	-0.532	-0.394	-0.466				
0.003	0.059	0.061	-0.010	-0.120				
0.130	0.123	0.113	-0.106	-0.069				
-0.943	-0.951	-0.953	-0.714	-0.472				
-0.451	-0.432	-0.437	-0.296	-0.310				
-0.135	-0.103	-0.111	-0.035	0.025				
-0.729	-0.721	-0.729	-0.580	-0.419				
-0.677	-0.671	-0.684	-0.545	-0.333				
-0.707	-0.673	-0.680	-0.578	-0.368				
-0.260	-0.211	-0.225	-0.152	-0.156				
-0.191	-0.159	-0.148	-0.147	-0.102				
-0.121	-0.097	-0.085	0.028	-0.090	-0.079	-0.155	-0.209	-0.171
0.033	0.068	0.077	0.112	0.078	0.033	-0.034	-0.107	-0.045
-0.139	-0.102	-0.132	-0.033	-0.119	-0.125	-0.187	-0.227	-0.191
-0.107	-0.083	-0.082	0.026	-0.069	-0.100	-0.163	-0.208	-0.174
0.234	0.242	0.245	0.303	0.249	0.278	0.229	0.186	0.210
-0.461	-0.457	-0.473	-0.408	-0.219	-0.378	-0.451	-0.507	-0.473
-0.405	-0.396	-0.394	-0.360	-0.250	-0.406	-0.470	-0.511	-0.469
-0.259	-0.241	-0.247	-0.239	-0.202	-0.251	-0.321	-0.359	-0.311

0.298	0.317	0.303	0.349	0.207	0.313	0.247	0.226	0.274
0.004	0.008	0.013	0.054	0.062	0.012	-0.061	-0.086	-0.038
-0.363	-0.375	-0.374	-0.359	-0.166	-0.383	-0.458	-0.497	-0.443
0.096	0.088	0.087	0.115	0.151	0.002	-0.059	-0.089	-0.040
0.131	0.139	0.141	0.101	0.100	0.072	0.020	-0.012	0.031
0.006	0.029	0.000	-0.031	0.017	-0.061	-0.091	-0.126	-0.090
-0.076	-0.049	-0.057	-0.114	-0.023	-0.083	-0.110	-0.144	-0.106
-0.106	-0.067	-0.086	-0.106	-0.097	-0.067	-0.091	-0.119	-0.087
0.057	0.084	0.088	0.042	0.060	0.106	0.088	0.072	0.106
-0.184	-0.148	-0.146	-0.266	-0.208	-0.102	-0.116	-0.139	-0.097
-0.027	0.027	0.036	-0.113	-0.064	0.090	0.090	0.074	0.106
0.554	0.577	0.575	0.499	0.423	0.644	0.656	0.660	0.686
-0.270	-0.263	-0.265	-0.320	-0.258	-0.231	-0.193	-0.217	-0.206
-0.237	-0.235	-0.230	-0.297	-0.232	-0.198	-0.153	-0.173	-0.161
-0.043	-0.034	-0.033	-0.063	-0.132	-0.011	0.051	0.037	0.041
0.123	0.134	0.138	0.149	0.032	0.137	0.226	0.229	0.217
0.170	0.180	0.180	0.230	0.121	0.179	0.268	0.285	0.248
0.098	0.103	0.109	0.145	0.038	0.065	0.144	0.199	0.137
0.268	0.240	0.241	0.311	0.100	0.190	0.269	0.362	0.267
0.192	0.147	0.159	0.205	0.063	0.077	0.143	0.240	0.139
0.083	0.033	0.049	0.115	0.083	0.047	0.113	0.203	0.092
-0.243	-0.293	-0.293	-0.281	-0.149	-0.262	-0.199	-0.110	-0.215
0.150	0.093	0.101	0.131	0.070	0.103	0.170	0.256	0.153
0.412	0.351	0.359	0.486	0.410	0.348	0.409	0.507	0.392
-0.095	-0.154	-0.142	-0.047	0.095	-0.110	-0.051	0.043	-0.072
-0.037	-0.086	-0.084	-0.057	-0.002	-0.106	-0.020	0.046	-0.051
0.206	0.150	0.168	0.175	0.278	0.102	0.188	0.246	0.147
0.232	0.186	0.198	0.189	0.279	0.123	0.210	0.258	0.163
0.510	0.470	0.475	0.479	0.488	0.375	0.463	0.507	0.402
0.675	0.637	0.656	0.692		0.550	0.645	0.717	0.604
0.383	0.351	0.381	0.370		0.270	0.364	0.439	0.325
0.222	0.181	0.218	0.233		0.102	0.199	0.289	0.174
0.496	0.490	0.502	0.547		0.385	0.484	0.543	0.466

0.124	0.104	0.110	0.106	0.074	0.089	0.141	0.182	0.131
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ERA-I	ERA5	JRA55	MERRA2	Sonde Avg	Sat Avg	Reanal Avg
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		-0.029		-0.124		
		-0.254		-0.193		
		-0.343		-0.233		
		-0.426		-0.357		
		-0.466		-0.404		
		-0.361		-0.253		
		-0.477		-0.382		
		-0.597		-0.667		
		-0.279		-0.308		
		-0.518		-0.480		
		-0.499		-0.542		
		0.005		0.041		
		-0.196		0.122		
		-0.788		-0.949		
		-0.296		-0.440		
		-0.103		-0.116		
		-0.695		-0.726		
		-0.661		-0.677		
		-0.597		-0.686		
		-0.187		-0.232		
		-0.195		-0.166		
0.082	0.016	-0.016		-0.101	-0.154	0.000
0.093	0.056	0.051	-0.007	0.059	-0.038	0.033
-0.086	-0.118	-0.116	-0.159	-0.124	-0.183	-0.131
-0.081	-0.113	-0.106	-0.181	-0.091	-0.161	-0.133
0.239	0.251	0.215	0.111	0.240	0.225	0.192
-0.376	-0.436	-0.418	-0.499	-0.463	-0.453	-0.451
-0.390	-0.430	-0.417	-0.544	-0.398	-0.464	-0.464
-0.228	-0.237	-0.235	-0.391	-0.249	-0.310	-0.288

0.289	0.325	0.296	0.149	0.306	0.265	0.257
0.044	0.079	0.020	0.029	0.008	-0.044	0.043
-0.366	-0.317	-0.373	-0.338	-0.371	-0.445	-0.343
0.047	0.124	0.043	0.048	0.090	-0.047	0.072
0.080	0.145	0.077	0.086	0.137	0.028	0.103
-0.099	0.009	-0.059	0.015	0.012	-0.092	-0.012
-0.106	-0.035	-0.079	-0.014	-0.061	-0.111	-0.042
-0.115	-0.075	-0.059	-0.012	-0.086	-0.091	-0.049
0.061	0.100	0.092	0.120	0.076	0.093	0.104
-0.160	-0.153	-0.132	-0.091	-0.159	-0.113	-0.125
0.026	0.043	0.064	0.129	0.012	0.090	0.079
0.529	0.603	0.622	0.675	0.569	0.661	0.633
-0.316	-0.293	-0.259	-0.249	-0.266	-0.212	-0.267
-0.246	-0.340	-0.222	-0.215	-0.234	-0.171	-0.259
-0.043	-0.149	-0.056	-0.022	-0.037	0.029	-0.076
0.118	0.072	0.144	0.183	0.132	0.202	0.133
0.182	0.129	0.186	0.251	0.177	0.245	0.189
0.093	0.030	0.087	0.170	0.103	0.136	0.096
0.263	0.161	0.255	0.313	0.250	0.272	0.243
0.176	0.100	0.129	0.146	0.166	0.150	0.125
0.114	0.095	0.053	0.087	0.055	0.114	0.078
-0.197	-0.197	-0.256	-0.224	-0.276	-0.197	-0.226
0.162	0.172	0.122	0.107	0.115	0.170	0.134
0.386	0.455	0.381	0.321	0.374	0.414	0.386
-0.064	-0.039	-0.084	-0.120	-0.130	-0.048	-0.081
-0.043	-0.055	-0.064	-0.098	-0.069	-0.033	-0.072
0.185	0.203	0.155	0.102	0.175	0.171	0.154
0.213	0.228	0.186	0.148	0.205	0.188	0.188
0.474	0.496	0.436	0.390	0.485	0.437	0.441
0.675	0.673	0.657	0.569	0.656	0.629	0.633
0.467	0.410	0.350	0.317	0.372	0.350	0.359
0.343	0.237	0.189	0.170	0.207	0.191	0.199
	0.542	0.483	0.499	0.496	0.469	0.508
0.110	0.113	0.109	0.125	0.113	0.136	0.113
						#DIV/0!

300-200 Tropics

	RAOBCOR	RICH	RATPAC A	ERA-I	ERA5	JRA55	MERRA2
1955							
1956							
1957							
1958	0.208	-0.06917	-0.112				
1959	-0.057	-0.2125	-0.596				
1960	-0.185	-0.25417	-0.509				
1961	-0.530	-0.55917	-0.682				
1962	-0.463	-0.47125	-0.519				
1963	-0.371	-0.38083	-0.632				
1964	-0.603	-0.56208	-0.622				
1965	-0.964	-0.93417	-0.792				
1966	-0.448	-0.42042	-0.216				
1967	-0.773	-0.71958	-0.579				
1968	-0.765	-0.7925	-0.662				
1969	0.042	-0.00167	-0.106				
1970	0.148	0.314583	-0.192				
1971	-1.394	-1.19333	-1.106				
1972	-0.566	-0.5175	-0.392				
1973	-0.118	-0.05	-0.139				
1974	-0.971	-0.81292	-0.846				
1975	-1.013	-0.83583	-0.812				
1976	-0.974	-0.99042	-0.812				
1977	-0.198	-0.28375	-0.149				
1978	-0.146	-0.20125	-0.229				
1979	-0.055	-0.08708	0.081	0.137	0.111		
1980	0.087	0.03	0.121	0.09	0.068		
1981	-0.227	-0.31917	-0.139	-0.207	-0.225		
1982	-0.240	-0.34625	-0.099	-0.32	-0.281		
1983	0.269	0.2275	0.244	0.188	0.268		
1984	-0.715	-0.74667	-0.722	-0.705	-0.709		
1985	-0.595	-0.64	-0.626	-0.727	-0.695		
1986	-0.207	-0.23292	-0.286	-0.376	-0.291		

1987	0.533	0.500417	0.581	0.472	0.545
1988	0.040	0.051667	0.104	0.069	0.122
1989	-0.592	-0.53375	-0.406	-0.547	-0.515
1990	0.092	0.120417	0.218	0.047	0.11
1991	0.170	0.11125	0.164	0.117	0.17
1992	-0.087	-0.15708	-0.146	-0.172	-0.08
1993	-0.099	-0.17458	-0.219	-0.208	-0.111
1994	-0.031	-0.13125	-0.159	-0.15	-0.08
1995	0.125	0.101667	0.028	0.11	0.132
1996	-0.150	-0.17958	-0.406	-0.18	-0.185
1997	0.154	0.057917	-0.059	0.146	0.162
1998	0.906	0.97375	0.741	0.934	0.964
1999	-0.459	-0.34542	-0.486	-0.376	-0.473
2000	-0.323	-0.19958	-0.426	-0.289	-0.495
2001	-0.056	0.037083	-0.106	0.022	-0.222
2002	0.307	0.350417	0.278	0.263	0.197
2003	0.328	0.3775	0.374	0.311	0.242
2004	0.185	0.239167	0.234	0.195	0.126
2005	0.432	0.54375	0.531	0.486	0.374
2006	0.186	0.37	0.278	0.327	0.202
2007	0.065	0.262917	0.188	0.201	0.198
2008	-0.579	-0.37208	-0.512	-0.376	-0.326
2009	0.138	0.319583	0.194	0.234	0.281
2010	0.389	0.555	0.641	0.622	0.669
2011	-0.328	-0.17917	-0.166	-0.111	-0.073
2012	-0.167	-0.01542	-0.119	-0.078	-0.052
2013	0.176	0.329583	0.214	0.289	0.31
2014	0.300	0.43375	0.281	0.352	0.387
2015	0.628	0.73375	0.644	0.707	0.71
2016	0.995	1.095833	1.051	1.057	1.046
2017	0.496	0.605417	0.538	0.447	0.548
2018	0.275	0.4075	0.307667	0.151	0.325
2019	0.752	0.881667	0.837667		

10.000	0.151	0.216	0.164	0.171	0.168	#DIV/0!	#DIV/0!
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		300-150 Tropics		
Sonde Ave	Reanalyses	RAOBCORE	RICH	RATPAC A
		1955		
		1956		
		1957		
0.009		1958	0.336875	0.02625
-0.288		1959	0.0715625	-0.13625
-0.316		1960	-0.0813542	-0.2227083
-0.590		1961	-0.4471875	-0.505625
-0.484		1962	-0.37	-0.4173958
-0.461		1963	-0.3263542	-0.3891667
-0.596		1964	-0.5069792	-0.5215625
-0.897		1965	-0.8857292	-0.89625
-0.361		1966	-0.4047917	-0.4096875
-0.691		1967	-0.6953125	-0.6667708
-0.740		1968	-0.7072917	-0.7489583
-0.022		1969	0.01802083	-0.0364583
0.090		1970	0.221875	0.3009375
-1.231		1971	-1.2984375	-1.1929167
-0.492		1972	-0.5988542	-0.6325
-0.102		1973	-0.1235417	-0.1077083
-0.877		1974	-0.8926042	-0.7869792
-0.887		1975	-0.9366667	-0.8064583
-0.926		1976	-0.9136458	-0.9090625
-0.210		1977	-0.2307292	-0.2928125
-0.192		1978	-0.1497917	-0.1957292
-0.020	0.124	1979	-0.0586458	-0.0792708
0.079	0.079	1980	0.048125	0.00645833
-0.228	-0.216	1981	-0.22125	-0.294375
-0.229	-0.3005	1982	-0.2248958	-0.3065625
0.247	0.228	1983	0.26604167	0.23729167
-0.728	-0.707	1984	-0.7134375	-0.731875
-0.620	-0.711	1985	-0.5903125	-0.6447917
-0.242	-0.3335	1986	-0.19625	-0.2384375

0.538	0.5085	1987	0.50739583	0.4578125
0.065	0.0955	1988	0.05302083	0.05666667
-0.511	-0.531	1989	-0.5178125	-0.4369792
0.143	0.0785	1990	0.12770833	0.1978125
0.149	0.1435	1991	0.20104167	0.18885417
-0.130	-0.126	1992	-0.05	-0.0815625
-0.164	-0.1595	1993	-0.0991667	-0.1584375
-0.107	-0.115	1994	-0.0135417	-0.1034375
0.085	0.121	1995	0.13770833	0.08479167
-0.245	-0.1825	1996	-0.1130208	-0.1892708
0.051	0.154	1997	0.19822917	0.06885417
0.874	0.949	1998	0.89947917	0.91385417
-0.430	-0.4245	1999	-0.4115625	-0.3505208
-0.316	-0.392	2000	-0.306875	-0.2221875
-0.041	-0.1	2001	-0.0627083	0.01552083
0.312	0.23	2002	0.25770833	0.3028125
0.360	0.2765	2003	0.24895833	0.30645833
0.220	0.1605	2004	0.13760417	0.20125
0.502	0.43	2005	0.3728125	0.49614583
0.278	0.2645	2006	0.09510417	0.29145833
0.172	0.1995	2007	-0.0069792	0.20552083
-0.488	-0.351	2008	-0.6084375	-0.3832292
0.217	0.2575	2009	0.04802083	0.24947917
0.528	0.6455	2010	0.33083333	0.51229167
-0.224	-0.092	2011	-0.3404167	-0.1714583
-0.101	-0.065	2012	-0.2344792	-0.0519792
0.240	0.2995	2013	0.0928125	0.26677083
0.338	0.3695	2014	0.2065625	0.3653125
0.669	0.7085	2015	0.51354167	0.6459375
1.047	1.0515	2016	0.86322917	0.98875
0.546	0.4975	2017	0.371875	0.5028125
0.330	0.238	2018	0.18583333	0.33020833
0.824		2019	0.61114583	0.751875

0.177	0.170	10.000	0.116	0.184	#DIV/0!
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ERA-I	ERA5	JRA55	MERRA2	Sonde Ave	Reanalyses
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0.182

-0.032

-0.152

-0.476

-0.394

-0.358

-0.514

-0.891

-0.407

-0.681

-0.728

-0.009

0.261

-1.246

-0.616

-0.116

-0.840

-0.872

-0.911

-0.262

-0.173

0.015

-0.069

0.015

0.027

0.027

0.027

-0.212

-0.258

-0.212

-0.293

-0.266

-0.293

0.237

0.252

0.237

-0.716

-0.723

-0.716

-0.661

-0.618

-0.661

-0.273

-0.217

-0.273

0.495	0.483	0.495
0.124	0.055	0.124
-0.493	-0.477	-0.493
0.104	0.163	0.104
0.183	0.195	0.183
-0.061	-0.066	-0.061
-0.119	-0.129	-0.119
-0.086	-0.058	-0.086
0.118	0.111	0.118
-0.193	-0.151	-0.193
0.151	0.134	0.151
0.912	0.907	0.912
-0.429	-0.381	-0.429
-0.49	-0.265	-0.49
-0.21	-0.024	-0.21
0.177	0.280	0.177
0.206	0.278	0.206
0.113	0.169	0.113
0.347	0.434	0.347
0.178	0.193	0.178
0.225	0.099	0.225
-0.283	-0.496	-0.283
0.288	0.149	0.288
0.682	0.422	0.682
-0.024	-0.256	-0.024
-0.031	-0.143	-0.031
0.315	0.180	0.315
0.375	0.286	0.375
0.698	0.580	0.698
1	0.926	1
0.514	0.437	0.514
0.312	0.258	0.312
	0.682	

#DIV/0!	0.172	#DIV/0!	#DIV/0!	0.150	0.172
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250-100

	RAOBCORE RICH	RATPAC A	ERA-I	ERA5	JRA55	MERRA2
1955						
1956						
1957						
1958	0.614	0.334				
1959	0.432	0.159				
1960	0.111	-0.122				
1961	0.002	-0.137				
1962	-0.087	-0.222				
1963	0.033	-0.129				
1964	-0.010	-0.138				
1965	-0.449	-0.538				
1966	-0.169	-0.261				
1967	-0.319	-0.344				
1968	-0.472	-0.527				
1969	0.050	-0.018				
1970	0.417	0.337				
1971	-0.922	-0.995				
1972	-0.599	-0.768				
1973	-0.024	-0.142				
1974	-0.637	-0.683				
1975	-0.644	-0.660				
1976	-0.639	-0.592				
1977	-0.271	-0.257				
1978	-0.161	-0.164				
1979	-0.083	-0.049		-0.077		
1980	-0.053	-0.055		-0.005		
1981	-0.172	-0.197		-0.082		
1982	-0.029	-0.060		-0.099		
1983	0.391	0.378		0.394		
1984	-0.583	-0.586		-0.541		
1985	-0.511	-0.564		-0.504		
1986	-0.253	-0.291		-0.221		

1987	0.382	0.324			0.359
1988	0.078	0.056			0.187
1989	-0.306	-0.198			-0.365
1990	0.207	0.336			0.131
1991	0.295	0.354			0.262
1992	0.093	0.112			0.052
1993	0.066	0.029			0.021
1994	0.029	-0.046			-0.091
1995	0.150	0.025			0.099
1996	-0.132	-0.267			-0.279
1997	0.202	0.078			0.016
1998	0.802	0.736			0.694
1999	-0.220	-0.261			-0.212
2000	-0.298	-0.299			-0.456
2001	-0.179	-0.134			-0.332
2002	-0.020	0.037			-0.048
2003	0.049	0.115			0.034
2004	-0.029	0.041			-0.048
2005	0.127	0.236			0.139
2006	-0.034	0.126			0.072
2007	-0.152	0.010			0.193
2008	-0.520	-0.368			-0.171
2009	-0.131	-0.002			0.221
2010	0.227	0.345			0.578
2011	-0.221	-0.100			0.106
2012	-0.386	-0.219			-0.107
2013	-0.073	0.100			0.197
2014	-0.033	0.124			0.290
2015	0.279	0.425			0.550
2016	0.432	0.566			0.692
2017	0.111	0.246			0.398
2018	0.000	0.124			0.221
2019	0.338	0.457			

10.000	0.029	0.081	#DIV/0!	#DIV/0!	0.110	#DIV/0!	#DIV/0!
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		TTT			RAOBCOF RICH		RATPAC / ERA-I		ERA5	
Sonde Ave	Reanalyses				RAOBCOF RICH		RATPAC / UAH		RSSv4.0	
		1955								
		1956								
		1957								
0.474		1958			0.038	-0.101	0.024			
0.295		1959			-0.200	-0.245	-0.385			
-0.005		1960			-0.276	-0.286	-0.369			
-0.067		1961			-0.482	-0.591	-0.560			
-0.154		1962			-0.466	-0.503	-0.459			
-0.048		1963			-0.391	-0.413	-0.507			
-0.074		1964			-0.536	-0.594	-0.540			
-0.494		1965			-0.788	-0.966	-0.719			
-0.215		1966			-0.398	-0.452	-0.286			
-0.331		1967			-0.605	-0.752	-0.532			
-0.500		1968			-0.629	-0.825	-0.520			
0.016		1969			0.017	-0.034	-0.111			
0.377		1970			0.047	0.283	-0.199			
-0.959		1971			-1.090	-1.225	-0.915			
-0.684		1972			-0.459	-0.550	-0.380			
-0.083		1973			-0.137	-0.082	-0.124			
-0.660		1974			-0.815	-0.845	-0.695			
-0.652		1975			-0.796	-0.868	-0.702			
-0.615		1976			-0.782	-1.022	-0.722			
-0.264		1977			-0.212	-0.316	-0.202			
-0.163		1978			-0.188	-0.233	-0.238			
-0.066	-0.077	1979			-0.093	-0.119	-0.029	-0.104	-0.169	
-0.054	-0.005	1980			0.045	-0.002	0.023	-0.013	-0.075	
-0.184	-0.082	1981			-0.171	-0.351	-0.099	-0.172	-0.232	
-0.044	-0.099	1982			-0.202	-0.378	-0.170	-0.218	-0.281	
0.385	0.394	1983			0.180	0.195	0.200	0.207	0.160	
-0.585	-0.541	1984			-0.507	-0.779	-0.456	-0.408	-0.480	
-0.538	-0.504	1985			-0.453	-0.672	-0.461	-0.475	-0.539	
-0.272	-0.221	1986			-0.231	-0.265	-0.267	-0.252	-0.320	

0.353	0.359	1987	0.328	0.468	0.347	0.348	0.281
0.067	0.187	1988	0.017	0.020	0.048	0.015	-0.060
-0.252	-0.365	1989	-0.452	-0.566	-0.449	-0.464	-0.541
0.271	0.131	1990	0.026	0.088	0.023	-0.062	-0.125
0.325	0.262	1991	0.086	0.079	0.032	0.025	-0.031
0.103	0.052	1992	-0.116	-0.189	-0.132	-0.177	-0.211
0.047	0.021	1993	-0.096	-0.207	-0.132	-0.127	-0.150
-0.008	-0.091	1994	-0.061	-0.163	-0.071	-0.041	-0.062
0.088	0.099	1995	0.099	0.070	0.080	0.125	0.108
-0.199	-0.279	1996	-0.119	-0.212	-0.216	-0.050	-0.065
0.140	0.016	1997	0.040	0.026	-0.086	0.114	0.116
0.769	0.694	1998	0.657	0.942	0.578	0.748	0.757
-0.240	-0.212	1999	-0.334	-0.377	-0.400	-0.297	-0.257
-0.298	-0.456	2000	-0.222	-0.232	-0.306	-0.197	-0.148
-0.157	-0.332	2001	-0.009	0.005	-0.075	-0.002	0.066
0.008	-0.048	2002	0.231	0.318	0.205	0.208	0.302
0.082	0.034	2003	0.257	0.345	0.280	0.245	0.338
0.006	-0.048	2004	0.153	0.207	0.187	0.102	0.185
0.182	0.139	2005	0.357	0.512	0.422	0.303	0.379
0.046	0.072	2006	0.170	0.338	0.223	0.089	0.157
-0.071	0.193	2007	0.114	0.231	0.200	0.115	0.175
-0.444	-0.171	2008	-0.327	-0.404	-0.294	-0.288	-0.224
-0.067	0.221	2009	0.177	0.288	0.222	0.176	0.239
0.286	0.578	2010	0.412	0.523	0.564	0.411	0.465
-0.160	0.106	2011	-0.172	-0.211	-0.036	-0.125	-0.068
-0.303	-0.107	2012	-0.026	-0.047	0.020	-0.043	0.044
0.013	0.197	2013	0.197	0.298	0.222	0.137	0.221
0.046	0.290	2014	0.268	0.402	0.281	0.187	0.269
0.352	0.550	2015	0.517	0.702	0.538	0.407	0.498
0.499	0.692	2016	0.812	1.064	0.866	0.702	0.793
0.178	0.398	2017	0.465	0.573	0.477	0.352	0.438
0.062	0.221	2018	0.275	0.375	0.299	0.169	0.261
0.398		2019	0.624	0.850	0.684	0.511	0.617

0.055	0.110		0.147	0.216	0.160	0.128	0.179
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0.98587	1	0.97852	0.97511	0.93924
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JRA55 MERRA2 Sonde Av Reanalyses

NOAA UW ERA5 JRA55 MERRA2 Sonde Av Sat Avg Reanalyses Avg

			-0.092		-0.013		
			-0.395		-0.277		
			-0.424		-0.310		
			-0.598		-0.544		
			-0.558		-0.476		
			-0.509		-0.437		
			-0.670		-0.557		
			-0.718		-0.824		
			-0.388		-0.379		
			-0.672		-0.629		
			-0.590		-0.658		
			-0.052		-0.043		
			-0.231		0.043		
			-0.918		-1.077		
			-0.317		-0.463		
			-0.143		-0.114		
			-0.767		-0.785		
			-0.764		-0.789		
			-0.690		-0.842		
			-0.182		-0.243		
			-0.243		-0.220		
-0.245	-0.204	-0.009	-0.018		-0.080	-0.186	-0.013
-0.171	-0.103	-0.006	0.014	-0.043	0.022	-0.089	-0.011
-0.285	-0.245	-0.180	-0.160	-0.201	-0.207	-0.238	-0.180
-0.338	-0.300	-0.238	-0.212	-0.295	-0.250	-0.291	-0.248
0.102	0.128	0.175	0.146	0.033	0.192	0.144	0.118
-0.556	-0.517	-0.483	-0.445	-0.531	-0.581	-0.499	-0.487
-0.589	-0.542	-0.512	-0.476	-0.612	-0.529	-0.541	-0.534
-0.367	-0.313	-0.255	-0.231	-0.408	-0.254	-0.316	-0.298

0.255	0.308	0.333	0.332	0.169	0.381	0.294	0.278
-0.096	-0.043	0.067	0.017	0.033	0.028	-0.052	0.039
-0.588	-0.529	-0.395	-0.452	-0.407	-0.489	-0.535	-0.418
-0.161	-0.107	0.061	-0.024	-0.014	0.046	-0.116	0.007
-0.067	-0.019	0.091	0.025	0.039	0.066	-0.025	0.051
-0.247	-0.207	-0.097	-0.168	-0.083	-0.146	-0.209	-0.116
-0.185	-0.142	-0.063	-0.122	-0.040	-0.145	-0.146	-0.075
-0.087	-0.051	-0.048	-0.034	0.033	-0.098	-0.056	-0.016
0.095	0.133	0.122	0.091	0.145	0.083	0.116	0.119
-0.089	-0.041	-0.103	-0.106	-0.037	-0.182	-0.058	-0.082
0.100	0.136	0.077	0.076	0.166	-0.007	0.115	0.107
0.765	0.793	0.703	0.711	0.778	0.726	0.761	0.731
-0.281	-0.269	-0.354	-0.319	-0.315	-0.371	-0.275	-0.329
-0.170	-0.156	-0.311	-0.215	-0.210	-0.253	-0.163	-0.245
0.052	0.056	-0.114	-0.030	-0.004	-0.026	0.054	-0.049
0.306	0.295	0.162	0.226	0.260	0.251	0.298	0.216
0.357	0.317	0.209	0.261	0.323	0.294	0.328	0.265
0.246	0.179	0.082	0.130	0.209	0.182	0.182	0.140
0.480	0.376	0.279	0.366	0.419	0.430	0.377	0.355
0.268	0.156	0.121	0.145	0.153	0.243	0.157	0.139
0.280	0.158	0.153	0.114	0.142	0.181	0.167	0.136
-0.116	-0.232	-0.228	-0.283	-0.262	-0.342	-0.228	-0.258
0.339	0.226	0.237	0.194	0.157	0.229	0.233	0.196
0.577	0.451	0.510	0.443	0.360	0.500	0.458	0.438
0.040	-0.086	-0.054	-0.100	-0.159	-0.140	-0.077	-0.104
0.121	0.015	0.000	-0.003	-0.057	-0.018	0.029	-0.020
0.288	0.180	0.231	0.189	0.113	0.239	0.200	0.178
0.324	0.221	0.287	0.249	0.187	0.317	0.245	0.241
0.552	0.437	0.533	0.474	0.405	0.586	0.468	0.470
0.874	0.751	0.817	0.819	0.694	0.914	0.772	0.777
0.522	0.398	0.488	0.438	0.374	0.505	0.418	0.433
0.359	0.232	0.297	0.264	0.215	0.316	0.246	0.258
0.650	0.568	0.659	0.612	0.601	0.719	0.592	0.624

0.226	0.170	0.154	0.147	0.157	0.174	0.174	0.150
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#DIV/0!	#DIV/0!	0.99272	0.9854
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From: John Christy <climateman60@gmail.com>
Sent: Wednesday, May 21, 2025 10:49 AM
To: Ross McKittrick
Cc: Judith Curry; Roy W. Spencer; Steve Koonin
Subject: Re: Model-obs comparison in troposphere
Attachments: CMIP6_20250521_Ross.xlsx

Ross

Here is the updated observations tab through 2024. Note this is 5 years to the day that I sent the data for the 2019 paper.

BE CAREFUL as I had to adjust the columns in the OBS tab to include NOAA satellite data and I eliminated ERA-I in a couple of places. So, make sure you are reading the correct columns

I do not trust the radiosondes for these values because (a) they are geographically deficient, especially in tropics and SH and (b) there are known biases that have yet to be corrected (e.g. the Vaisala software update in 2010 shifted tropospheric temperatures by 0.15°C upward - which is why their trends are warmer than the satellites). These radiosonde errors bleed into the reanalyses too, so the satellites are in general the most stable (though RSS still has yet to correct their spurious warming due to NOAA-14 drift.). UAH and NOAA data, though built in very different ways, are almost identical in trends.

John C.

On Tue, May 20, 2025 at 8:18 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

It needs to match the formatting of the attached: each model on a separate sheet, columns and rows positioned just so.

On Tue, May 20, 2025 at 9:12 PM John Christy <climateman60@gmail.com> wrote:

Ross

I can reformat if you could send what you need.

John C.

Sent from my iPhone

On May 20, 2025, at 7:37 PM, Ross McKittrick <ross.mckittrick@gmail.com> wrote:

The updated data you sent are formatted very differently from the earlier spreadsheets and would take a lot of coding to get into the program.

On Tue, May 20, 2025 at 8:35 PM John Christy <climateman60@gmail.com> wrote:
Oh, I see through 2018.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 20, 2025, at 7:04 PM, Ross McKittrick <ross.mckittrick@gmail.com> wrote:

Is this better?

<image.png>

Figure 5.4: Observed versus modeled warming trends in the global lower (LT) and mid-troposphere (MT). Adapted from McKittrick and Christy (2020). Blue dots: warming trends ($^{\circ}\text{C}/\text{decade}$ 1979-2018) with 95% confidence interval bars for 3 data products (satellite, radiosondes and reanalysis) and 95% confidence interval bars. Blue dashed line: warming trend average for 3 observed series. Red dots: modeled warming trends in 36 models.

LT Global

	RAOBCOR	RICH17	RATPAC	UAHv6.0	RSSv4.0	NOAA	Avg Sat	ERA5
1958	-0.444	-0.528	-0.513					-0.395
1959	-0.463	-0.562	-0.601					-0.454
1960	-0.508	-0.612	-0.619					-0.571
1961	-0.455	-0.578	-0.568					-0.523
1962	-0.614	-0.727	-0.706					-0.613
1963	-0.583	-0.687	-0.689					-0.582
1964	-0.710	-0.810	-0.933					-0.755
1965	-0.804	-0.907	-0.947					-0.805
1966	-0.640	-0.736	-0.721					-0.560
1967	-0.622	-0.706	-0.725					-0.661
1968	-0.766	-0.859	-0.797					-0.724
1969	-0.521	-0.619	-0.582					-0.452
1970	-0.489	-0.545	-0.577					-0.507
1971	-0.811	-0.865	-0.862					-0.801
1972	-0.625	-0.689	-0.685					-0.616
1973	-0.328	-0.398	-0.426					-0.373
1974	-0.720	-0.767	-0.783					-0.783
1975	-0.692	-0.743	-0.739					-0.730
1976	-0.860	-0.931	-0.922					-0.860
1977	-0.433	-0.527	-0.451					-0.427
1978	-0.440	-0.532	-0.545					-0.490
1979	-0.360	-0.442	-0.414	-0.346	-0.495		-0.421	-0.303
1980	-0.213	-0.287	-0.275	-0.178	-0.344		-0.261	-0.235
1981	-0.240	-0.306	-0.282	-0.248	-0.358	-0.272	-0.293	-0.261
1982	-0.466	-0.530	-0.518	-0.433	-0.560	-0.393	-0.462	-0.466
1983	-0.267	-0.321	-0.362	-0.178	-0.327	-0.131	-0.212	-0.235
1984	-0.533	-0.586	-0.567	-0.374	-0.590	-0.402	-0.455	-0.504
1985	-0.493	-0.553	-0.530	-0.498	-0.645	-0.438	-0.527	-0.535
1986	-0.403	-0.481	-0.487	-0.356	-0.528	-0.274	-0.386	-0.413

1987	-0.125	-0.201	-0.242	-0.087	-0.233	0.033	-0.096	-0.135
1988	-0.112	-0.160	-0.196	-0.098	-0.264	0.012	-0.117	-0.090
1989	-0.373	-0.409	-0.446	-0.346	-0.467	-0.234	-0.349	-0.318
1990	-0.085	-0.113	-0.210	-0.124	-0.290	-0.015	-0.143	-0.065
1991	-0.083	-0.112	-0.245	-0.116	-0.245	0.006	-0.118	-0.090
1992	-0.414	-0.447	-0.512	-0.417	-0.518	-0.289	-0.408	-0.376
1993	-0.330	-0.366	-0.446	-0.339	-0.453	-0.275	-0.356	-0.346
1994	-0.266	-0.297	-0.293	-0.201	-0.318	-0.152	-0.224	-0.255
1995	-0.201	-0.227	-0.190	-0.067	-0.177	-0.053	-0.099	-0.141
1996	-0.324	-0.343	-0.369	-0.146	-0.278	-0.156	-0.193	-0.246
1997	-0.298	-0.316	-0.324	-0.144	-0.242	-0.159	-0.182	-0.245
1998	0.232	0.220	0.155	0.347	0.224	0.306	0.292	0.220
1999	-0.253	-0.259	-0.303	-0.153	-0.243	-0.211	-0.202	-0.280
2000	-0.284	-0.291	-0.326	-0.157	-0.248	-0.221	-0.208	-0.315
2001	-0.119	-0.137	-0.132	-0.022	-0.079	-0.061	-0.054	-0.130
2002	0.016	-0.006	-0.031	0.080	0.033	0.035	0.049	-0.001
2003	0.009	-0.008	0.024	0.050	0.048	0.014	0.037	-0.012
2004	-0.088	-0.091	-0.081	-0.056	-0.024	-0.088	-0.056	-0.104
2005	0.093	0.106	0.141	0.063	0.110	0.040	0.071	0.044
2006	-0.017	0.000	0.065	-0.023	0.020	-0.044	-0.016	-0.035
2007	0.042	0.059	0.050	0.023	0.055	0.000	0.026	0.015
2008	-0.254	-0.239	-0.199	-0.238	-0.153	-0.250	-0.214	-0.240
2009	-0.012	-0.001	0.013	-0.043	0.009	-0.043	-0.025	-0.027
2010	0.140	0.151	0.233	0.194	0.254	0.197	0.215	0.250
2011	-0.130	-0.115	-0.034	-0.120	-0.072	-0.109	-0.100	-0.075
2012	-0.059	-0.044	0.022	-0.084	-0.006	-0.084	-0.058	-0.035
2013	0.073	0.091	0.136	-0.001	0.069	0.004	0.024	0.068
2014	0.117	0.138	0.167	0.044	0.127	0.056	0.075	0.113
2015	0.270	0.287	0.302	0.137	0.260	0.154	0.183	0.221
2016	0.595	0.610	0.554	0.388	0.456	0.389	0.411	0.499
2017	0.355	0.373	0.382	0.265	0.332	0.240	0.279	0.359
2018	0.249	0.268	0.264	0.088	0.193	0.101	0.127	0.233
2019	0.470	0.492	0.481	0.296	0.401	0.293	0.330	0.437
2020	0.475	0.505	0.495	0.351	0.465	0.361	0.392	0.495
2021	0.238	0.275	0.298	0.138	0.271	0.184	0.197	0.290
2022	0.267	0.228	0.320	0.15	0.254	0.192	0.199	0.300
2023	0.515	0.530	0.573	0.432	0.551	0.475	0.486	0.585
2024	0.860	0.875	0.924	0.774	0.860	0.784	0.806	0.914
2025								
79-24	0.195	0.217	0.232	0.152	0.228	0.146	0.176	0.195
95-19	0.243	0.263	0.277	0.108	0.210	0.126	0.148	0.225

0.444
0.405
0.340
0.374
0.196
0.207
0.060
-0.053
0.091
0.089
-0.074
0.152
0.164

-0.178		
-0.011		
0.267		
-0.145		
-0.137		
-0.323		
0.083		
0.057		
0.117	0.102	0.160
0.245	0.235	0.276
0.199	0.194	0.246
-0.047	-0.051	-0.014
0.132	0.136	0.119
-0.153	-0.151	-0.108
-0.132	-0.140	-0.095
-0.062	-0.089	-0.075
0.196	0.168	0.147
0.190	0.188	0.170
-0.091	-0.083	-0.103
0.178	0.191	0.109
0.160	0.171	0.051
-0.190	-0.186	-0.239
-0.126	-0.127	-0.196
-0.081	-0.079	-0.066
-0.035	-0.031	0.014
-0.179	-0.169	-0.188
-0.172	-0.164	-0.167
0.338	0.350	0.289
-0.166	-0.150	-0.192
-0.217	-0.204	-0.238
-0.071	-0.072	-0.068
0.044	0.038	0.011
0.018	0.014	0.042
-0.099	-0.091	-0.086
0.063	0.084	0.113
-0.066	-0.043	0.014
-0.027	-0.006	-0.024
-0.342	-0.326	-0.296
-0.120	-0.110	-0.107
0.012	0.020	0.090
-0.277	-0.267	-0.201
-0.226	-0.218	-0.168
-0.113	-0.105	-0.077
-0.089	-0.080	-0.069
0.045	0.047	0.043
0.351	0.350	0.271

0.091	0.090	0.077
-0.035	-0.036	-0.065
0.167	0.166	0.129
0.152	0.157	0.119
-0.104	-0.095	-0.101
-0.094	-0.163	-0.102
0.154	0.138	0.151
0.498	0.484	0.503

					LT Tropics		
JRA3Q	MERRA	Sonde Ave	Sat Avg	Reanal Avg	RAOBCOR RICH		
-0.568		-0.495		-0.482	1958	-0.215	-0.368
-0.658		-0.542		-0.556	1959	-0.436	-0.556
-0.730		-0.580		-0.651	1960	-0.398	-0.558
-0.711		-0.533		-0.617	1961	-0.605	-0.810
-0.788		-0.682		-0.700	1962	-0.610	-0.808
-0.738		-0.653		-0.660	1963	-0.500	-0.683
-0.837		-0.818		-0.796	1964	-0.623	-0.809
-0.909		-0.886		-0.857	1965	-0.747	-0.933
-0.710		-0.699		-0.635	1966	-0.430	-0.611
-0.795		-0.685		-0.728	1967	-0.662	-0.818
-0.865		-0.807		-0.794	1968	-0.671	-0.858
-0.580		-0.574		-0.516	1969	-0.159	-0.339
-0.685		-0.537		-0.596	1970	-0.193	-0.230
-0.939		-0.846		-0.870	1971	-1.076	-1.103
-0.751		-0.667		-0.684	1972	-0.469	-0.537
-0.552		-0.384		-0.462	1973	-0.303	-0.397
-0.923		-0.757		-0.853	1974	-0.902	-0.978
-0.870		-0.725		-0.800	1975	-0.882	-0.973
-0.979		-0.904		-0.919	1976	-0.829	-0.981
-0.585		-0.471		-0.506	1977	-0.331	-0.505
-0.616		-0.506		-0.553	1978	-0.294	-0.442
-0.405		-0.405	-0.421	-0.354	1979	-0.197	-0.326
-0.303	-0.222	-0.258	-0.261	-0.253	1980	-0.127	-0.243
-0.337	-0.268	-0.276	-0.293	-0.289	1981	-0.272	-0.380
-0.481	-0.511	-0.505	-0.462	-0.486	1982	-0.340	-0.448
-0.268	-0.315	-0.317	-0.212	-0.273	1983	-0.038	-0.111
-0.547	-0.552	-0.562	-0.455	-0.534	1984	-0.544	-0.597
-0.566	-0.600	-0.525	-0.527	-0.567	1985	-0.513	-0.573
-0.430	-0.509	-0.457	-0.386	-0.450	1986	-0.321	-0.422

-0.130	-0.228	-0.189	-0.096	-0.164	1987	0.126	0.034
-0.105	-0.138	-0.156	-0.117	-0.111	1988	-0.160	-0.231
-0.359	-0.403	-0.409	-0.349	-0.360	1989	-0.581	-0.637
-0.119	-0.185	-0.136	-0.143	-0.123	1990	-0.096	-0.158
-0.130	-0.201	-0.147	-0.118	-0.140	1991	-0.067	-0.138
-0.408	-0.464	-0.458	-0.408	-0.416	1992	-0.210	-0.269
-0.392	-0.421	-0.381	-0.356	-0.386	1993	-0.236	-0.284
-0.265	-0.292	-0.285	-0.224	-0.270	1994	-0.219	-0.257
-0.146	-0.166	-0.206	-0.099	-0.151	1995	-0.047	-0.078
-0.231	-0.272	-0.346	-0.193	-0.250	1996	-0.269	-0.299
-0.228	-0.244	-0.313	-0.182	-0.239	1997	-0.144	-0.192
0.260	0.221	0.202	0.292	0.234	1998	0.331	0.303
-0.215	-0.242	-0.272	-0.202	-0.246	1999	-0.532	-0.539
-0.243	-0.249	-0.301	-0.208	-0.269	2000	-0.388	-0.395
-0.063	-0.061	-0.129	-0.054	-0.085	2001	-0.173	-0.198
0.033	0.078	-0.007	0.049	0.037	2002	0.070	0.034
0.033	0.111	0.008	0.037	0.044	2003	0.067	0.036
-0.049	0.034	-0.087	-0.056	-0.040	2004	-0.037	-0.044
0.118	0.181	0.113	0.071	0.114	2005	0.131	0.158
0.018	0.058	0.016	-0.016	0.013	2006	-0.018	0.022
-0.005	0.056	0.050	0.026	0.022	2007	-0.056	-0.015
-0.252	-0.172	-0.231	-0.214	-0.221	2008	-0.424	-0.392
-0.049	-0.022	0.000	-0.025	-0.033	2009	0.095	0.123
0.223	0.186	0.174	0.215	0.220	2010	0.198	0.221
-0.071	-0.097	-0.093	-0.100	-0.081	2011	-0.341	-0.312
-0.036	-0.050	-0.027	-0.058	-0.041	2012	-0.098	-0.075
0.058	0.007	0.100	0.024	0.044	2013	0.052	0.080
0.092	0.074	0.140	0.075	0.093	2014	0.119	0.139
0.197	0.175	0.286	0.183	0.198	2015	0.333	0.346
0.463	0.427	0.587	0.411	0.463	2016	0.637	0.647
0.307	0.301	0.370	0.279	0.322	2017	0.311	0.331
0.172	0.188	0.260	0.127	0.198	2018	0.108	0.143
0.368	0.428	0.481	0.330	0.411	2019	0.424	0.463
0.433	0.434	0.491	0.392	0.454	2020	0.383	0.438
0.234	0.270	0.270	0.197	0.265	2021	0.013	0.085
0.282	0.341	0.272	0.199	0.308	2022	-0.014	-0.112
0.571	0.653	0.539	0.486	0.603	2023	0.502	0.581
0.884	0.973	0.886	0.806	0.924	2024	0.920	0.999
					2025		
0.198	0.216	0.215	0.176	0.202		0.155	0.190
0.182	0.183	0.261	0.148	0.197			

RATPAC	UAH	RSS4.0	NOAA	ERA5	JRA3Q	MERRA-2	Sonde Ave	Sat Avg
-0.098				-0.215	-0.357		-0.227	
-0.488				-0.487	-0.625		-0.493	
-0.489				-0.570	-0.691		-0.482	
-0.707				-0.686	-0.812		-0.707	
-0.631				-0.680	-0.761		-0.683	
-0.576				-0.598	-0.661		-0.586	
-0.715				-0.750	-0.750		-0.716	
-0.884				-0.776	-0.802		-0.855	
-0.471				-0.443	-0.532		-0.504	
-0.730				-0.771	-0.804		-0.737	
-0.637				-0.726	-0.793		-0.722	
-0.264				-0.205	-0.269		-0.254	
-0.398				-0.417	-0.503		-0.274	
-1.007				-1.008	-1.099		-1.062	
-0.570				-0.466	-0.540		-0.525	
-0.306				-0.305	-0.444		-0.335	
-0.868				-0.928	-1.000		-0.916	
-0.884				-0.921	-1.000		-0.913	
-0.921				-0.849	-0.937		-0.910	
-0.436				-0.388	-0.495		-0.424	
-0.422				-0.428	-0.505		-0.386	
-0.252	-0.359	-0.293		-0.148	-0.238		-0.258	-0.326
-0.159	-0.228	-0.210		-0.165	-0.234	-0.214	-0.176	-0.219
-0.271	-0.359	-0.378	-0.330	-0.333	-0.378	-0.371	-0.308	-0.356
-0.369	-0.372	-0.405	-0.278	-0.373	-0.349	-0.437	-0.386	-0.352
-0.055	0.029	-0.045	0.147	-0.018	-0.020	-0.162	-0.068	0.044
-0.538	-0.443	-0.565	-0.439	-0.552	-0.570	-0.674	-0.560	-0.482
-0.557	-0.585	-0.686	-0.483	-0.603	-0.605	-0.758	-0.548	-0.585
-0.452	-0.346	-0.463	-0.235	-0.400	-0.387	-0.581	-0.398	-0.348

0.103	0.179	0.069	0.325	0.126	0.137	-0.036	0.088	0.191
-0.168	-0.134	-0.241	-0.002	-0.119	-0.152	-0.182	-0.187	-0.126
-0.623	-0.554	-0.622	-0.413	-0.504	-0.563	-0.568	-0.614	-0.530
-0.189	-0.191	-0.281	-0.041	-0.099	-0.166	-0.198	-0.148	-0.171
-0.185	-0.124	-0.196	0.019	-0.089	-0.145	-0.160	-0.130	-0.100
-0.282	-0.308	-0.347	-0.160	-0.243	-0.273	-0.240	-0.254	-0.272
-0.297	-0.245	-0.296	-0.155	-0.212	-0.268	-0.222	-0.272	-0.232
-0.241	-0.167	-0.257	-0.114	-0.204	-0.223	-0.177	-0.239	-0.179
-0.080	0.005	-0.103	0.028	-0.040	-0.087	-0.065	-0.068	-0.023
-0.344	-0.153	-0.258	-0.183	-0.217	-0.266	-0.231	-0.304	-0.198
-0.245	-0.021	-0.105	-0.049	-0.089	-0.116	-0.020	-0.193	-0.058
0.333	0.548	0.408	0.483	0.447	0.444	0.492	0.322	0.480
-0.530	-0.384	-0.462	-0.451	-0.498	-0.452	-0.464	-0.534	-0.432
-0.441	-0.280	-0.366	-0.366	-0.428	-0.360	-0.363	-0.408	-0.337
-0.214	-0.106	-0.177	-0.168	-0.249	-0.160	-0.154	-0.195	-0.150
0.023	0.079	0.043	0.023	-0.034	0.038	0.071	0.042	0.048
0.076	0.109	0.088	0.060	0.017	0.094	0.156	0.060	0.086
0.031	-0.031	-0.004	-0.067	-0.112	-0.011	0.069	-0.017	-0.034
0.205	0.148	0.173	0.109	0.070	0.177	0.224	0.165	0.143
0.064	-0.046	-0.012	-0.069	-0.094	0.001	0.009	0.023	-0.042
0.013	-0.022	0.007	-0.045	-0.042	-0.063	-0.033	-0.019	-0.020
-0.368	-0.384	-0.310	-0.387	-0.358	-0.379	-0.356	-0.394	-0.360
0.046	0.029	0.086	0.022	0.061	0.039	0.017	0.088	0.046
0.350	0.221	0.248	0.225	0.286	0.253	0.167	0.256	0.231
-0.190	-0.272	-0.227	-0.261	-0.224	-0.224	-0.292	-0.281	-0.253
-0.089	-0.183	-0.113	-0.180	-0.136	-0.130	-0.194	-0.087	-0.159
0.084	-0.032	0.036	-0.016	0.059	0.054	-0.036	0.072	-0.004
0.087	0.015	0.080	0.026	0.087	0.081	0.020	0.115	0.040
0.327	0.222	0.309	0.252	0.315	0.300	0.242	0.336	0.261
0.627	0.497	0.540	0.503	0.588	0.557	0.486	0.637	0.513
0.290	0.201	0.253	0.200	0.300	0.245	0.207	0.311	0.218
0.112	0.010	0.102	0.030	0.134	0.072	0.055	0.121	0.047
0.442	0.332	0.434	0.336	0.458	0.397	0.411	0.443	0.367
0.393	0.345	0.423	0.354	0.449	0.419	0.384	0.405	0.374
0.137	-0.006	0.102	0.049	0.120	0.090	0.088	0.078	0.048
-0.070	-0.129	-0.054	-0.071	-0.014	-0.025	-0.009	-0.065	-0.085
0.482	0.433	0.497	0.469	0.550	0.547	0.594	0.522	0.466
0.939	0.923	0.946	0.909	1.016	0.997	1.066	0.953	0.926

0.175	0.141	0.182	0.122	0.165	0.169	0.187	0.173	0.148
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MT GL						
		RAOBCOR RICH	RATPAC A UNSW		UAH	
Reanal Avg	1955					
	1956					
	1957					
-0.286	1958	-0.165	-0.292	-0.254		
-0.556	1959	-0.228	-0.354	-0.338	-0.138	
-0.630	1960	-0.246	-0.373	-0.356	-0.214	
-0.749	1961	-0.251	-0.390	-0.325	-0.223	
-0.721	1962	-0.433	-0.549	-0.461	-0.331	
-0.630	1963	-0.290	-0.382	-0.336	-0.257	
-0.750	1964	-0.338	-0.438	-0.506	-0.307	
-0.789	1965	-0.608	-0.713	-0.659	-0.402	
-0.487	1966	-0.379	-0.481	-0.409	-0.247	
-0.788	1967	-0.410	-0.495	-0.457	-0.339	
-0.759	1968	-0.553	-0.629	-0.535	-0.434	
-0.237	1969	-0.309	-0.397	-0.293	-0.195	
-0.460	1970	-0.258	-0.309	-0.318	-0.203	
-1.053	1971	-0.645	-0.691	-0.611	-0.415	
-0.503	1972	-0.483	-0.547	-0.444	-0.343	
-0.374	1973	-0.151	-0.235	-0.204	-0.054	
-0.964	1974	-0.550	-0.615	-0.556	-0.340	
-0.961	1975	-0.467	-0.536	-0.490	-0.237	
-0.893	1976	-0.646	-0.748	-0.659	-0.445	
-0.441	1977	-0.227	-0.360	-0.202	-0.095	
-0.466	1978	-0.237	-0.372	-0.305	-0.175	
-0.193	1979	-0.195	-0.293	-0.161	-0.112	-0.213
-0.204	1980	-0.060	-0.156	-0.058	0.022	-0.062
-0.361	1981	-0.155	-0.237	-0.133	-0.070	-0.154
-0.386	1982	-0.238	-0.306	-0.209	-0.092	-0.230
-0.067	1983	-0.097	-0.147	-0.103	0.063	-0.034
-0.598	1984	-0.420	-0.481	-0.389	-0.196	-0.353
-0.655	1985	-0.427	-0.498	-0.388	-0.241	-0.402
-0.456	1986	-0.316	-0.402	-0.335	-0.193	-0.313

0.076	1987	-0.006	-0.090	-0.016	0.092	-0.009
-0.151	1988	-0.031	-0.074	-0.049	0.063	-0.038
-0.545	1989	-0.283	-0.298	-0.311	-0.128	-0.291
-0.154	1990	0.009	0.005	-0.060	0.109	-0.075
-0.131	1991	0.053	0.040	-0.040	0.117	-0.009
-0.252	1992	-0.207	-0.231	-0.269	-0.097	-0.222
-0.234	1993	-0.298	-0.325	-0.368	-0.140	-0.300
-0.202	1994	-0.226	-0.249	-0.231	-0.075	-0.183
-0.064	1995	-0.217	-0.238	-0.217	-0.065	-0.103
-0.238	1996	-0.320	-0.333	-0.331	-0.191	-0.163
-0.075	1997	-0.289	-0.299	-0.275	-0.118	-0.126
0.461	1998	0.235	0.230	0.202	0.367	0.324
-0.472	1999	-0.278	-0.283	-0.293	-0.096	-0.181
-0.383	2000	-0.318	-0.327	-0.315	-0.165	-0.206
-0.188	2001	-0.118	-0.145	-0.107	-0.001	-0.040
0.025	2002	0.010	-0.020	0.045	0.093	0.092
0.089	2003	0.007	-0.019	0.044	0.125	0.046
-0.018	2004	-0.070	-0.081	-0.043	0.034	-0.040
0.157	2005	0.058	0.061	0.110	0.140	0.048
-0.028	2006	-0.017	-0.008	0.035	0.087	-0.046
-0.046	2007	0.006	0.015	0.010	0.171	-0.007
-0.364	2008	-0.269	-0.263	-0.248	-0.084	-0.256
0.039	2009	-0.026	-0.024	-0.021	0.089	-0.041
0.235	2010	0.187	0.194	0.240	0.403	0.207
-0.247	2011	-0.126	-0.114	-0.097	0.085	-0.142
-0.153	2012	-0.061	-0.052	-0.024	0.095	-0.077
0.026	2013	0.106	0.114	0.119	0.249	0.044
0.063	2014	0.105	0.116	0.100	0.256	0.052
0.286	2015	0.245	0.257	0.260	0.403	0.141
0.544	2016	0.511	0.523	0.449		0.357
0.251	2017	0.297	0.317	0.279		0.215
0.087	2018	0.196	0.227	0.181		0.052
0.422	2019	0.382	0.419	0.382		0.263
0.418	2020	0.443	0.498	0.423		0.301
0.099	2021	0.172	0.238	0.209		0.063
-0.016	2022	0.201	0.204	0.217		0.066
0.564	2023	0.423	0.429	0.459		0.334
1.026	2024	0.857	0.864	0.881		0.722
	2025					

0.171		0.146	0.171	0.151	0.092	0.113
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RSS	NOAA	ERA5	JRA3Q	MERRA2	Sonde Ave	Sat Avg	Reanal Avg
		-0.132	-0.202		-0.237		
		-0.215	-0.331		-0.307		
		-0.353	-0.390		-0.325		
		-0.299	-0.393		-0.322		
		-0.438	-0.511		-0.481		
		-0.315	-0.395		-0.336		
		-0.404	-0.443		-0.427		
		-0.608	-0.623		-0.660		
		-0.326	-0.382		-0.423		
		-0.449	-0.513		-0.454		
		-0.529	-0.594		-0.573		
		-0.233	-0.288		-0.333		
		-0.324	-0.391		-0.295		
		-0.614	-0.686		-0.649		
		-0.456	-0.519		-0.491		
		-0.197	-0.300		-0.197		
		-0.600	-0.696		-0.574		
		-0.484	-0.600		-0.497		
		-0.625	-0.739		-0.684		
		-0.197	-0.330		-0.263		
		-0.243	-0.361		-0.304		
-0.317	-0.231	-0.114	-0.175		-0.216	-0.254	-0.144
-0.153	-0.072	-0.058	-0.088	-0.124	-0.091	-0.096	-0.090
-0.245	-0.149	-0.163	-0.190	-0.233	-0.175	-0.183	-0.195
-0.319	-0.235	-0.237	-0.240	-0.331	-0.251	-0.261	-0.269
-0.116	-0.024	-0.063	-0.074	-0.188	-0.116	-0.058	-0.108
-0.445	-0.357	-0.401	-0.397	-0.502	-0.430	-0.385	-0.433
-0.490	-0.386	-0.433	-0.420	-0.558	-0.438	-0.426	-0.471
-0.415	-0.283	-0.308	-0.290	-0.446	-0.351	-0.337	-0.348

-0.115	0.062	-0.013	0.020	-0.153	-0.037	-0.021	-0.049
-0.146	0.028	0.011	0.045	-0.066	-0.051	-0.052	-0.003
-0.405	-0.229	-0.248	-0.225	-0.344	-0.298	-0.308	-0.272
-0.178	-0.009	0.002	-0.005	-0.120	-0.015	-0.087	-0.041
-0.103	0.053	0.054	0.025	-0.072	0.018	-0.020	0.002
-0.291	-0.179	-0.163	-0.199	-0.261	-0.236	-0.231	-0.207
-0.367	-0.266	-0.299	-0.313	-0.381	-0.330	-0.311	-0.331
-0.242	-0.150	-0.223	-0.202	-0.283	-0.236	-0.191	-0.236
-0.169	-0.082	-0.176	-0.156	-0.225	-0.224	-0.118	-0.186
-0.220	-0.160	-0.268	-0.232	-0.309	-0.328	-0.181	-0.270
-0.173	-0.133	-0.239	-0.206	-0.263	-0.287	-0.144	-0.236
0.291	0.312	0.217	0.277	0.202	0.222	0.309	0.232
-0.188	-0.221	-0.288	-0.225	-0.269	-0.284	-0.197	-0.261
-0.204	-0.247	-0.341	-0.276	-0.300	-0.320	-0.219	-0.306
-0.021	-0.072	-0.152	-0.109	-0.079	-0.124	-0.044	-0.113
0.124	0.058	0.027	0.047	0.108	0.012	0.091	0.061
0.079	0.019	-0.015	0.015	0.101	0.011	0.048	0.034
-0.020	-0.070	-0.072	-0.042	0.052	-0.065	-0.043	-0.021
0.070	0.027	0.026	0.074	0.147	0.076	0.048	0.082
-0.023	-0.061	-0.038	-0.021	0.035	0.003	-0.043	-0.008
0.007	-0.019	0.000	-0.019	0.044	0.010	-0.006	0.008
-0.240	-0.263	-0.244	-0.263	-0.196	-0.260	-0.253	-0.235
-0.027	-0.050	-0.024	-0.053	-0.008	-0.024	-0.039	-0.029
0.218	0.196	0.269	0.238	0.223	0.207	0.207	0.243
-0.121	-0.138	-0.113	-0.118	-0.126	-0.112	-0.134	-0.119
-0.053	-0.078	-0.054	-0.052	-0.049	-0.045	-0.069	-0.052
0.067	0.037	0.105	0.086	0.068	0.113	0.049	0.086
0.080	0.058	0.108	0.075	0.085	0.107	0.063	0.089
0.174	0.151	0.202	0.173	0.180	0.254	0.155	0.185
0.387	0.366	0.435	0.396	0.387	0.494	0.370	0.406
0.245	0.223	0.302	0.268	0.262	0.298	0.228	0.278
0.088	0.077	0.152	0.113	0.135	0.201	0.072	0.133
0.296	0.280	0.378	0.325	0.393	0.395	0.280	0.365
0.336	0.331	0.435	0.372	0.400	0.455	0.323	0.402
0.107	0.125	0.209	0.152	0.200	0.206	0.098	0.187
0.105	0.131	0.214	0.204	0.257	0.208	0.101	0.225
0.374	0.408	0.492	0.464	0.555	0.437	0.372	0.504
0.758	0.773	0.908	0.853	0.969	0.867	0.751	0.910

0.152	0.114	0.143	0.134	0.182	0.156	0.126	0.150
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MT Tropics

	RAOB AVC	RAOBCOR	RICH	RATPAC A	UNSW	UAH	RSS	NOAA
1955								
1956								
1957								
1958	-0.262	-0.031	-0.253	-0.025				
1959	-0.289	-0.182	-0.533	-0.348	-0.310			
1960	-0.276	-0.256	-0.424	-0.391	-0.383			
1961	-0.391	-0.386	-0.603	-0.500	-0.366			
1962	-0.436	-0.485	-0.696	-0.481	-0.415			
1963	-0.294	-0.302	-0.477	-0.452	-0.298			
1964	-0.421	-0.337	-0.582	-0.451	-0.367			
1965	-0.700	-0.551	-0.798	-0.693	-0.402			
1966	-0.338	-0.213	-0.460	-0.276	-0.207			
1967	-0.506	-0.429	-0.634	-0.488	-0.400			
1968	-0.576	-0.567	-0.729	-0.527	-0.466			
1969	0.003	-0.058	-0.213	-0.142	-0.120			
1970	0.130	-0.005	-0.030	-0.238	-0.069			
1971	-0.943	-0.978	-1.003	-0.847	-0.472			
1972	-0.451	-0.435	-0.514	-0.429	-0.310			
1973	-0.135	-0.172	-0.297	-0.167	0.025			
1974	-0.729	-0.775	-0.885	-0.713	-0.419			
1975	-0.677	-0.756	-0.870	-0.678	-0.333			
1976	-0.707	-0.720	-0.912	-0.711	-0.368			
1977	-0.260	-0.262	-0.489	-0.285	-0.156			
1978	-0.191	-0.197	-0.396	-0.279	-0.102			
1979	-0.121	-0.189	-0.303	-0.105	-0.090	-0.186	-0.310	-0.161
1980	0.033	-0.082	-0.205	-0.020	0.078	-0.072	-0.189	-0.043
1981	-0.139	-0.243	-0.355	-0.165	-0.119	-0.231	-0.343	-0.183
1982	-0.107	-0.217	-0.304	-0.107	-0.069	-0.207	-0.318	-0.162
1983	0.234	0.098	0.057	0.170	0.249	0.173	0.074	0.240
1984	-0.461	-0.593	-0.637	-0.541	-0.219	-0.485	-0.606	-0.454
1985	-0.405	-0.524	-0.580	-0.493	-0.250	-0.512	-0.626	-0.462
1986	-0.259	-0.322	-0.435	-0.372	-0.202	-0.359	-0.476	-0.285

1987	0.298	0.189	0.088	0.217	0.207	0.205	0.091	0.317
1988	0.004	-0.133	-0.184	-0.078	0.062	-0.094	-0.216	0.002
1989	-0.363	-0.538	-0.547	-0.491	-0.166	-0.491	-0.613	-0.405
1990	0.096	0.002	-0.009	-0.017	0.151	-0.107	-0.214	-0.013
1991	0.131	0.027	-0.015	-0.031	0.100	-0.034	-0.135	0.054
1992	0.006	-0.084	-0.125	-0.164	0.017	-0.167	-0.247	-0.098
1993	-0.076	-0.200	-0.227	-0.247	-0.023	-0.191	-0.265	-0.139
1994	-0.106	-0.225	-0.247	-0.239	-0.097	-0.174	-0.246	-0.128
1995	0.057	-0.079	-0.106	-0.091	0.060	-0.001	-0.067	0.028
1996	-0.184	-0.365	-0.392	-0.398	-0.208	-0.208	-0.271	-0.203
1997	-0.027	-0.157	-0.205	-0.246	-0.064	-0.020	-0.065	-0.024
1998	0.554	0.365	0.337	0.368	0.423	0.541	0.507	0.524
1999	-0.270	-0.484	-0.490	-0.455	-0.258	-0.338	-0.348	-0.407
2000	-0.237	-0.421	-0.426	-0.430	-0.232	-0.306	-0.308	-0.373
2001	-0.043	-0.194	-0.225	-0.196	-0.132	-0.119	-0.104	-0.174
2002	0.123	0.011	-0.029	0.016	0.032	0.030	0.070	-0.002
2003	0.170	0.048	0.009	0.097	0.121	0.074	0.111	0.044
2004	0.098	-0.052	-0.064	0.011	0.038	-0.042	-0.014	-0.073
2005	0.268	0.079	0.102	0.178	0.100	0.087	0.111	0.065
2006	0.192	0.041	0.072	0.072	0.063	-0.029	-0.015	-0.057
2007	0.083	-0.068	-0.041	-0.019	0.083	-0.058	-0.046	-0.069
2008	-0.243	-0.424	-0.409	-0.415	-0.149	-0.369	-0.358	-0.382
2009	0.150	0.046	0.057	-0.002	0.070	-0.005	0.010	-0.015
2010	0.412	0.237	0.250	0.353	0.410	0.243	0.249	0.229
2011	-0.095	-0.276	-0.254	-0.182	0.095	-0.217	-0.211	-0.231
2012	-0.037	-0.175	-0.161	-0.190	-0.002	-0.215	-0.181	-0.208
2013	0.206	0.066	0.082	0.041	0.278	-0.003	0.028	-0.004
2014	0.232	0.113	0.121	0.057	0.279	0.017	0.049	0.023
2015	0.510	0.383	0.390	0.346	0.488	0.266	0.302	0.275
2016	0.675	0.576	0.580	0.562		0.446	0.484	0.465
2017	0.383	0.273	0.297	0.246		0.163	0.204	0.185
2018	0.222	0.106	0.157	0.101		-0.006	0.038	0.020
2019	0.409	0.381	0.437	0.408		0.276	0.322	0.305
2020		0.451	0.523	0.448		0.358	0.395	0.371
2021		0.087	0.179	0.213		0.029	0.075	0.070
2022		0.080	0.055	0.021		-0.062	-0.031	-0.027
2023		0.512	0.554	0.499		0.407	0.447	0.464
2024		0.966	1.008	0.957		0.855	0.895	0.902
2025								

	0.121	0.147	0.178	0.139	0.074	0.113	0.158	0.102
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UW	ERA-I	ERA5	JRA3Q	MERRA2	Sonde Avg	Sat Avg	Reanal Avg
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		-0.055	-0.139		-0.103		
		-0.270	-0.367		-0.354		
		-0.431	-0.516		-0.357		
		-0.441	-0.552		-0.496		
		-0.520	-0.577		-0.554		
		-0.386	-0.448		-0.410		
		-0.475	-0.500		-0.457		
		-0.655	-0.674		-0.681		
		-0.286	-0.347		-0.316		
		-0.569	-0.601		-0.517		
		-0.612	-0.678		-0.608		
		-0.084	-0.121		-0.138		
		-0.329	-0.373		-0.091		
		-0.919	-0.983		-0.943		
		-0.445	-0.480		-0.459		
		-0.209	-0.301		-0.212		
		-0.830	-0.895		-0.791		
		-0.784	-0.872		-0.768		
		-0.694	-0.800		-0.781		
		-0.295	-0.403		-0.345		
		-0.265	-0.353		-0.291		
-0.171	0.082	-0.109	-0.152		-0.199	-0.219	-0.130
-0.045	0.093	-0.074	-0.116	-0.163	-0.102	-0.101	-0.118
-0.191	-0.086	-0.250	-0.272	-0.319	-0.255	-0.252	-0.280
-0.174	-0.081	-0.235	-0.221	-0.315	-0.210	-0.229	-0.257
0.210	0.239	0.130	0.128	-0.024	0.108	0.162	0.078
-0.473	-0.376	-0.580	-0.582	-0.727	-0.590	-0.515	-0.630
-0.469	-0.390	-0.565	-0.550	-0.761	-0.533	-0.533	-0.625
-0.311	-0.228	-0.382	-0.364	-0.596	-0.377	-0.373	-0.447

0.274	0.289	0.189	0.203	-0.014	0.165	0.204	0.126
-0.038	0.044	-0.058	-0.064	-0.138	-0.132	-0.103	-0.086
-0.443	-0.366	-0.452	-0.458	-0.511	-0.525	-0.503	-0.474
-0.040	0.047	-0.005	-0.031	-0.080	-0.008	-0.111	-0.039
0.031	0.080	0.018	-0.029	-0.052	-0.006	-0.038	-0.021
-0.090	-0.099	-0.109	-0.144	-0.105	-0.124	-0.171	-0.119
-0.106	-0.106	-0.172	-0.203	-0.168	-0.225	-0.198	-0.181
-0.087	-0.115	-0.225	-0.222	-0.203	-0.237	-0.183	-0.217
0.106	0.061	-0.045	-0.042	-0.038	-0.092	-0.013	-0.041
-0.097	-0.160	-0.305	-0.301	-0.280	-0.385	-0.227	-0.295
0.106	0.026	-0.109	-0.085	-0.016	-0.202	-0.036	-0.070
0.686	0.529	0.460	0.499	0.536	0.356	0.524	0.498
-0.206	-0.316	-0.435	-0.380	-0.402	-0.477	-0.364	-0.405
-0.161	-0.246	-0.442	-0.373	-0.393	-0.426	-0.329	-0.403
0.041	-0.043	-0.252	-0.196	-0.180	-0.205	-0.132	-0.209
0.217	0.118	-0.062	-0.038	0.012	-0.001	0.033	-0.029
0.248	0.182	-0.003	0.032	0.107	0.051	0.076	0.045
0.137	0.093	-0.095	-0.054	0.038	-0.035	-0.043	-0.037
0.267	0.263	0.039	0.087	0.149	0.119	0.088	0.091
0.139	0.176	-0.025	0.006	0.025	0.062	-0.034	0.002
0.092	0.114	-0.057	-0.077	-0.059	-0.042	-0.058	-0.065
-0.215	-0.197	-0.342	-0.367	-0.357	-0.416	-0.370	-0.355
0.153	0.162	0.017	-0.009	-0.020	0.034	-0.003	-0.004
0.392	0.386	0.317	0.280	0.207	0.280	0.240	0.268
-0.072	-0.064	-0.175	-0.176	-0.239	-0.237	-0.220	-0.196
-0.051	-0.043	-0.213	-0.207	-0.259	-0.175	-0.201	-0.226
0.147	0.185	0.060	0.050	-0.023	0.063	0.007	0.029
0.163	0.213	0.076	0.057	0.010	0.097	0.030	0.048
0.402	0.474	0.345	0.334	0.290	0.373	0.281	0.323
0.604	0.675	0.513	0.486	0.427	0.573	0.465	0.475
0.325	0.467	0.254	0.226	0.175	0.272	0.184	0.218
0.174	0.343	0.085	0.053	0.028	0.121	0.017	0.055
0.466		0.380	0.341	0.357	0.409	0.301	0.360
		0.499	0.456	0.437	0.474	0.375	0.464
		0.190	0.150	0.148	0.160	0.058	0.162
		0.100	0.094	0.090	0.052	-0.040	0.095
		0.580	0.568	0.607	0.522	0.439	0.585
		1.040	0.993	1.067	0.977	0.884	1.033
0.131	0.110	0.148	0.144	0.173	0.155	0.124	0.152

300-200 Tropics

	RAOBCOR	RICH	RATPAC A	ERA-I	ERA5	JRA55	MERRA2
1955							
1956							
1957							
1958	0.208	-0.06917	-0.112				
1959	-0.057	-0.2125	-0.596				
1960	-0.185	-0.25417	-0.509				
1961	-0.530	-0.55917	-0.682				
1962	-0.463	-0.47125	-0.519				
1963	-0.371	-0.38083	-0.632				
1964	-0.603	-0.56208	-0.622				
1965	-0.964	-0.93417	-0.792				
1966	-0.448	-0.42042	-0.216				
1967	-0.773	-0.71958	-0.579				
1968	-0.765	-0.7925	-0.662				
1969	0.042	-0.00167	-0.106				
1970	0.148	0.314583	-0.192				
1971	-1.394	-1.19333	-1.106				
1972	-0.566	-0.5175	-0.392				
1973	-0.118	-0.05	-0.139				
1974	-0.971	-0.81292	-0.846				
1975	-1.013	-0.83583	-0.812				
1976	-0.974	-0.99042	-0.812				
1977	-0.198	-0.28375	-0.149				
1978	-0.146	-0.20125	-0.229				
1979	-0.055	-0.08708	0.081	0.137	0.111		
1980	0.087	0.03	0.121	0.09	0.068		
1981	-0.227	-0.31917	-0.139	-0.207	-0.225		
1982	-0.240	-0.34625	-0.099	-0.32	-0.281		
1983	0.269	0.2275	0.244	0.188	0.268		
1984	-0.715	-0.74667	-0.722	-0.705	-0.709		
1985	-0.595	-0.64	-0.626	-0.727	-0.695		
1986	-0.207	-0.23292	-0.286	-0.376	-0.291		

1987	0.533	0.500417	0.581	0.472	0.545
1988	0.040	0.051667	0.104	0.069	0.122
1989	-0.592	-0.53375	-0.406	-0.547	-0.515
1990	0.092	0.120417	0.218	0.047	0.11
1991	0.170	0.11125	0.164	0.117	0.17
1992	-0.087	-0.15708	-0.146	-0.172	-0.08
1993	-0.099	-0.17458	-0.219	-0.208	-0.111
1994	-0.031	-0.13125	-0.159	-0.15	-0.08
1995	0.125	0.101667	0.028	0.11	0.132
1996	-0.150	-0.17958	-0.406	-0.18	-0.185
1997	0.154	0.057917	-0.059	0.146	0.162
1998	0.906	0.97375	0.741	0.934	0.964
1999	-0.459	-0.34542	-0.486	-0.376	-0.473
2000	-0.323	-0.19958	-0.426	-0.289	-0.495
2001	-0.056	0.037083	-0.106	0.022	-0.222
2002	0.307	0.350417	0.278	0.263	0.197
2003	0.328	0.3775	0.374	0.311	0.242
2004	0.185	0.239167	0.234	0.195	0.126
2005	0.432	0.54375	0.531	0.486	0.374
2006	0.186	0.37	0.278	0.327	0.202
2007	0.065	0.262917	0.188	0.201	0.198
2008	-0.579	-0.37208	-0.512	-0.376	-0.326
2009	0.138	0.319583	0.194	0.234	0.281
2010	0.389	0.555	0.641	0.622	0.669
2011	-0.328	-0.17917	-0.166	-0.111	-0.073
2012	-0.167	-0.01542	-0.119	-0.078	-0.052
2013	0.176	0.329583	0.214	0.289	0.31
2014	0.300	0.43375	0.281	0.352	0.387
2015	0.628	0.73375	0.644	0.707	0.71
2016	0.995	1.095833	1.051	1.057	1.046
2017	0.496	0.605417	0.538	0.447	0.548
2018	0.275	0.4075	0.307667	0.151	0.325
2019	0.752	0.881667	0.837667		

0.151	0.216	0.164	0.171	0.168	#DIV/0!	#DIV/0!
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		300-150 Tropics		
Sonde Ave	Reanalyses	RAOBCORE	RICH	RATPAC A
		1955		
		1956		
		1957		
0.009		1958	0.336875	0.02625
-0.288		1959	0.0715625	-0.13625
-0.316		1960	-0.0813542	-0.2227083
-0.590		1961	-0.4471875	-0.505625
-0.484		1962	-0.37	-0.4173958
-0.461		1963	-0.3263542	-0.3891667
-0.596		1964	-0.5069792	-0.5215625
-0.897		1965	-0.8857292	-0.89625
-0.361		1966	-0.4047917	-0.4096875
-0.691		1967	-0.6953125	-0.6667708
-0.740		1968	-0.7072917	-0.7489583
-0.022		1969	0.01802083	-0.0364583
0.090		1970	0.221875	0.3009375
-1.231		1971	-1.2984375	-1.1929167
-0.492		1972	-0.5988542	-0.6325
-0.102		1973	-0.1235417	-0.1077083
-0.877		1974	-0.8926042	-0.7869792
-0.887		1975	-0.9366667	-0.8064583
-0.926		1976	-0.9136458	-0.9090625
-0.210		1977	-0.2307292	-0.2928125
-0.192		1978	-0.1497917	-0.1957292
-0.020	0.124	1979	-0.0586458	-0.0792708
0.079	0.079	1980	0.048125	0.00645833
-0.228	-0.216	1981	-0.22125	-0.294375
-0.229	-0.3005	1982	-0.2248958	-0.3065625
0.247	0.228	1983	0.26604167	0.23729167
-0.728	-0.707	1984	-0.7134375	-0.731875
-0.620	-0.711	1985	-0.5903125	-0.6447917
-0.242	-0.3335	1986	-0.19625	-0.2384375

0.538	0.5085	1987	0.50739583	0.4578125
0.065	0.0955	1988	0.05302083	0.05666667
-0.511	-0.531	1989	-0.5178125	-0.4369792
0.143	0.0785	1990	0.12770833	0.1978125
0.149	0.1435	1991	0.20104167	0.18885417
-0.130	-0.126	1992	-0.05	-0.0815625
-0.164	-0.1595	1993	-0.0991667	-0.1584375
-0.107	-0.115	1994	-0.0135417	-0.1034375
0.085	0.121	1995	0.13770833	0.08479167
-0.245	-0.1825	1996	-0.1130208	-0.1892708
0.051	0.154	1997	0.19822917	0.06885417
0.874	0.949	1998	0.89947917	0.91385417
-0.430	-0.4245	1999	-0.4115625	-0.3505208
-0.316	-0.392	2000	-0.306875	-0.2221875
-0.041	-0.1	2001	-0.0627083	0.01552083
0.312	0.23	2002	0.25770833	0.3028125
0.360	0.2765	2003	0.24895833	0.30645833
0.220	0.1605	2004	0.13760417	0.20125
0.502	0.43	2005	0.3728125	0.49614583
0.278	0.2645	2006	0.09510417	0.29145833
0.172	0.1995	2007	-0.0069792	0.20552083
-0.488	-0.351	2008	-0.6084375	-0.3832292
0.217	0.2575	2009	0.04802083	0.24947917
0.528	0.6455	2010	0.33083333	0.51229167
-0.224	-0.092	2011	-0.3404167	-0.1714583
-0.101	-0.065	2012	-0.2344792	-0.0519792
0.240	0.2995	2013	0.0928125	0.26677083
0.338	0.3695	2014	0.2065625	0.3653125
0.669	0.7085	2015	0.51354167	0.6459375
1.047	1.0515	2016	0.86322917	0.98875
0.546	0.4975	2017	0.371875	0.5028125
0.330	0.238	2018	0.18583333	0.33020833
0.824		2019	0.61114583	0.751875
		2020		
		2021		
		2022		
		2023		
		2024		
		2025		

0.177	0.170	#DIV/0!	10.000	0.116	0.184	#DIV/0!
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ERA-I	ERA5	JRA55	MERRA2	Sonde Ave	Reanalyses
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0.182

-0.032

-0.152

-0.476

-0.394

-0.358

-0.514

-0.891

-0.407

-0.681

-0.728

-0.009

0.261

-1.246

-0.616

-0.116

-0.840

-0.872

-0.911

-0.262

-0.173

0.015

-0.069

0.015

0.027

0.027

0.027

-0.212

-0.258

-0.212

-0.293

-0.266

-0.293

0.237

0.252

0.237

-0.716

-0.723

-0.716

-0.661

-0.618

-0.661

-0.273

-0.217

-0.273

0.495	0.483	0.495
0.124	0.055	0.124
-0.493	-0.477	-0.493
0.104	0.163	0.104
0.183	0.195	0.183
-0.061	-0.066	-0.061
-0.119	-0.129	-0.119
-0.086	-0.058	-0.086
0.118	0.111	0.118
-0.193	-0.151	-0.193
0.151	0.134	0.151
0.912	0.907	0.912
-0.429	-0.381	-0.429
-0.49	-0.265	-0.49
-0.21	-0.024	-0.21
0.177	0.280	0.177
0.206	0.278	0.206
0.113	0.169	0.113
0.347	0.434	0.347
0.178	0.193	0.178
0.225	0.099	0.225
-0.283	-0.496	-0.283
0.288	0.149	0.288
0.682	0.422	0.682
-0.024	-0.256	-0.024
-0.031	-0.143	-0.031
0.315	0.180	0.315
0.375	0.286	0.375
0.698	0.580	0.698
1	0.926	1
0.514	0.437	0.514
0.312	0.258	0.312
	0.682	

#DIV/0!	0.172	#DIV/0!	#DIV/0!	0.150	0.172	#DIV/0!
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250-100

	RAOBCORE RICH	RATPAC A	ERA-I	ERA5	JRA55	MERRA2
1955						
1956						
1957						
1958	0.614	0.334				
1959	0.432	0.159				
1960	0.111	-0.122				
1961	0.002	-0.137				
1962	-0.087	-0.222				
1963	0.033	-0.129				
1964	-0.010	-0.138				
1965	-0.449	-0.538				
1966	-0.169	-0.261				
1967	-0.319	-0.344				
1968	-0.472	-0.527				
1969	0.050	-0.018				
1970	0.417	0.337				
1971	-0.922	-0.995				
1972	-0.599	-0.768				
1973	-0.024	-0.142				
1974	-0.637	-0.683				
1975	-0.644	-0.660				
1976	-0.639	-0.592				
1977	-0.271	-0.257				
1978	-0.161	-0.164				
1979	-0.083	-0.049		-0.077		
1980	-0.053	-0.055		-0.005		
1981	-0.172	-0.197		-0.082		
1982	-0.029	-0.060		-0.099		
1983	0.391	0.378		0.394		
1984	-0.583	-0.586		-0.541		
1985	-0.511	-0.564		-0.504		
1986	-0.253	-0.291		-0.221		

1987	0.382	0.324			0.359
1988	0.078	0.056			0.187
1989	-0.306	-0.198			-0.365
1990	0.207	0.336			0.131
1991	0.295	0.354			0.262
1992	0.093	0.112			0.052
1993	0.066	0.029			0.021
1994	0.029	-0.046			-0.091
1995	0.150	0.025			0.099
1996	-0.132	-0.267			-0.279
1997	0.202	0.078			0.016
1998	0.802	0.736			0.694
1999	-0.220	-0.261			-0.212
2000	-0.298	-0.299			-0.456
2001	-0.179	-0.134			-0.332
2002	-0.020	0.037			-0.048
2003	0.049	0.115			0.034
2004	-0.029	0.041			-0.048
2005	0.127	0.236			0.139
2006	-0.034	0.126			0.072
2007	-0.152	0.010			0.193
2008	-0.520	-0.368			-0.171
2009	-0.131	-0.002			0.221
2010	0.227	0.345			0.578
2011	-0.221	-0.100			0.106
2012	-0.386	-0.219			-0.107
2013	-0.073	0.100			0.197
2014	-0.033	0.124			0.290
2015	0.279	0.425			0.550
2016	0.432	0.566			0.692
2017	0.111	0.246			0.398
2018	0.000	0.124			0.221
2019	0.338	0.457			
2020					
2021					
2022					
2023					
2024					
2025					

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		RAOBCOF RICH			RATPAC / ERA-I		ERA5	
		TTT						
Sonde Ave	Reanalyses	RAOBCOF RICH			RATPAC / UAH		RSSv4.0	
		1955						
		1956						
		1957						
0.474		1958	0.038	-0.101	0.024			
0.295		1959	-0.200	-0.245	-0.385			
-0.005		1960	-0.276	-0.286	-0.369			
-0.067		1961	-0.482	-0.591	-0.560			
-0.154		1962	-0.466	-0.503	-0.459			
-0.048		1963	-0.391	-0.413	-0.507			
-0.074		1964	-0.536	-0.594	-0.540			
-0.494		1965	-0.788	-0.966	-0.719			
-0.215		1966	-0.398	-0.452	-0.286			
-0.331		1967	-0.605	-0.752	-0.532			
-0.500		1968	-0.629	-0.825	-0.520			
0.016		1969	0.017	-0.034	-0.111			
0.377		1970	0.047	0.283	-0.199			
-0.959		1971	-1.090	-1.225	-0.915			
-0.684		1972	-0.459	-0.550	-0.380			
-0.083		1973	-0.137	-0.082	-0.124			
-0.660		1974	-0.815	-0.845	-0.695			
-0.652		1975	-0.796	-0.868	-0.702			
-0.615		1976	-0.782	-1.022	-0.722			
-0.264		1977	-0.212	-0.316	-0.202			
-0.163		1978	-0.188	-0.233	-0.238			
-0.066	-0.077	1979	-0.093	-0.119	-0.029	-0.104	-0.169	
-0.054	-0.005	1980	0.045	-0.002	0.023	-0.013	-0.075	
-0.184	-0.082	1981	-0.171	-0.351	-0.099	-0.172	-0.232	
-0.044	-0.099	1982	-0.202	-0.378	-0.170	-0.218	-0.281	
0.385	0.394	1983	0.180	0.195	0.200	0.207	0.160	
-0.585	-0.541	1984	-0.507	-0.779	-0.456	-0.408	-0.480	
-0.538	-0.504	1985	-0.453	-0.672	-0.461	-0.475	-0.539	
-0.272	-0.221	1986	-0.231	-0.265	-0.267	-0.252	-0.320	

0.353	0.359		1987	0.328	0.468	0.347	0.348	0.281
0.067	0.187		1988	0.017	0.020	0.048	0.015	-0.060
-0.252	-0.365		1989	-0.452	-0.566	-0.449	-0.464	-0.541
0.271	0.131		1990	0.026	0.088	0.023	-0.062	-0.125
0.325	0.262		1991	0.086	0.079	0.032	0.025	-0.031
0.103	0.052		1992	-0.116	-0.189	-0.132	-0.177	-0.211
0.047	0.021		1993	-0.096	-0.207	-0.132	-0.127	-0.150
-0.008	-0.091		1994	-0.061	-0.163	-0.071	-0.041	-0.062
0.088	0.099		1995	0.099	0.070	0.080	0.125	0.108
-0.199	-0.279		1996	-0.119	-0.212	-0.216	-0.050	-0.065
0.140	0.016		1997	0.040	0.026	-0.086	0.114	0.116
0.769	0.694		1998	0.657	0.942	0.578	0.748	0.757
-0.240	-0.212		1999	-0.334	-0.377	-0.400	-0.297	-0.257
-0.298	-0.456		2000	-0.222	-0.232	-0.306	-0.197	-0.148
-0.157	-0.332		2001	-0.009	0.005	-0.075	-0.002	0.066
0.008	-0.048		2002	0.231	0.318	0.205	0.208	0.302
0.082	0.034		2003	0.257	0.345	0.280	0.245	0.338
0.006	-0.048		2004	0.153	0.207	0.187	0.102	0.185
0.182	0.139		2005	0.357	0.512	0.422	0.303	0.379
0.046	0.072		2006	0.170	0.338	0.223	0.089	0.157
-0.071	0.193		2007	0.114	0.231	0.200	0.115	0.175
-0.444	-0.171		2008	-0.327	-0.404	-0.294	-0.288	-0.224
-0.067	0.221		2009	0.177	0.288	0.222	0.176	0.239
0.286	0.578		2010	0.412	0.523	0.564	0.411	0.465
-0.160	0.106		2011	-0.172	-0.211	-0.036	-0.125	-0.068
-0.303	-0.107		2012	-0.026	-0.047	0.020	-0.043	0.044
0.013	0.197		2013	0.197	0.298	0.222	0.137	0.221
0.046	0.290		2014	0.268	0.402	0.281	0.187	0.269
0.352	0.550		2015	0.517	0.702	0.538	0.407	0.498
0.499	0.692		2016	0.812	1.064	0.866	0.702	0.793
0.178	0.398		2017	0.465	0.573	0.477	0.352	0.438
0.062	0.221		2018	0.275	0.375	0.299	0.169	0.261
0.398			2019	0.624	0.850	0.684	0.511	0.617
			2020					
			2021					
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			2025					

0.055	0.110	#DIV/0!	10.000	0.147	0.216	0.160	0.128	0.179
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0.98587 1 0.97852 0.97511 0.93924

JRA55 MERRA2 Sonde Av Reanalyses

NOAA UW ERA5 JRA55 MERRA2 Sonde Av Sat Avg Reanalyses Avg

			-0.092		-0.013		
			-0.395		-0.277		
			-0.424		-0.310		
			-0.598		-0.544		
			-0.558		-0.476		
			-0.509		-0.437		
			-0.670		-0.557		
			-0.718		-0.824		
			-0.388		-0.379		
			-0.672		-0.629		
			-0.590		-0.658		
			-0.052		-0.043		
			-0.231		0.043		
			-0.918		-1.077		
			-0.317		-0.463		
			-0.143		-0.114		
			-0.767		-0.785		
			-0.764		-0.789		
			-0.690		-0.842		
			-0.182		-0.243		
			-0.243		-0.220		
-0.245	-0.204	-0.009	-0.018		-0.080	-0.186	-0.013
-0.171	-0.103	-0.006	0.014	-0.043	0.022	-0.089	-0.011
-0.285	-0.245	-0.180	-0.160	-0.201	-0.207	-0.238	-0.180
-0.338	-0.300	-0.238	-0.212	-0.295	-0.250	-0.291	-0.248
0.102	0.128	0.175	0.146	0.033	0.192	0.144	0.118
-0.556	-0.517	-0.483	-0.445	-0.531	-0.581	-0.499	-0.487
-0.589	-0.542	-0.512	-0.476	-0.612	-0.529	-0.541	-0.534
-0.367	-0.313	-0.255	-0.231	-0.408	-0.254	-0.316	-0.298

0.255	0.308	0.333	0.332	0.169	0.381	0.294	0.278
-0.096	-0.043	0.067	0.017	0.033	0.028	-0.052	0.039
-0.588	-0.529	-0.395	-0.452	-0.407	-0.489	-0.535	-0.418
-0.161	-0.107	0.061	-0.024	-0.014	0.046	-0.116	0.007
-0.067	-0.019	0.091	0.025	0.039	0.066	-0.025	0.051
-0.247	-0.207	-0.097	-0.168	-0.083	-0.146	-0.209	-0.116
-0.185	-0.142	-0.063	-0.122	-0.040	-0.145	-0.146	-0.075
-0.087	-0.051	-0.048	-0.034	0.033	-0.098	-0.056	-0.016
0.095	0.133	0.122	0.091	0.145	0.083	0.116	0.119
-0.089	-0.041	-0.103	-0.106	-0.037	-0.182	-0.058	-0.082
0.100	0.136	0.077	0.076	0.166	-0.007	0.115	0.107
0.765	0.793	0.703	0.711	0.778	0.726	0.761	0.731
-0.281	-0.269	-0.354	-0.319	-0.315	-0.371	-0.275	-0.329
-0.170	-0.156	-0.311	-0.215	-0.210	-0.253	-0.163	-0.245
0.052	0.056	-0.114	-0.030	-0.004	-0.026	0.054	-0.049
0.306	0.295	0.162	0.226	0.260	0.251	0.298	0.216
0.357	0.317	0.209	0.261	0.323	0.294	0.328	0.265
0.246	0.179	0.082	0.130	0.209	0.182	0.182	0.140
0.480	0.376	0.279	0.366	0.419	0.430	0.377	0.355
0.268	0.156	0.121	0.145	0.153	0.243	0.157	0.139
0.280	0.158	0.153	0.114	0.142	0.181	0.167	0.136
-0.116	-0.232	-0.228	-0.283	-0.262	-0.342	-0.228	-0.258
0.339	0.226	0.237	0.194	0.157	0.229	0.233	0.196
0.577	0.451	0.510	0.443	0.360	0.500	0.458	0.438
0.040	-0.086	-0.054	-0.100	-0.159	-0.140	-0.077	-0.104
0.121	0.015	0.000	-0.003	-0.057	-0.018	0.029	-0.020
0.288	0.180	0.231	0.189	0.113	0.239	0.200	0.178
0.324	0.221	0.287	0.249	0.187	0.317	0.245	0.241
0.552	0.437	0.533	0.474	0.405	0.586	0.468	0.470
0.874	0.751	0.817	0.819	0.694	0.914	0.772	0.777
0.522	0.398	0.488	0.438	0.374	0.505	0.418	0.433
0.359	0.232	0.297	0.264	0.215	0.316	0.246	0.258
0.650	0.568	0.659	0.612	0.601	0.719	0.592	0.624

0.226	0.170	0.154	0.147	0.157	0.174	0.174	0.150
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#DIV/0! #DIV/0! 0.99272 0.9854

From: Judith Curry [curry.judith@gmail.com]
Sent: 5/21/2025 12:59:01 AM
To: Ross McKittrick [ross.mckittrick@gmail.com]
CC: Roy W. Spencer [roywspencer@hotmail.com]; John Christy [climatemanager60@gmail.com]; Steven Koonin [steven.koonin@gmail.com]
Subject: Re: Model-obs comparison in troposphere

Yes, much better.

On Tue, May 20, 2025 at 5:04 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:
Is this better?

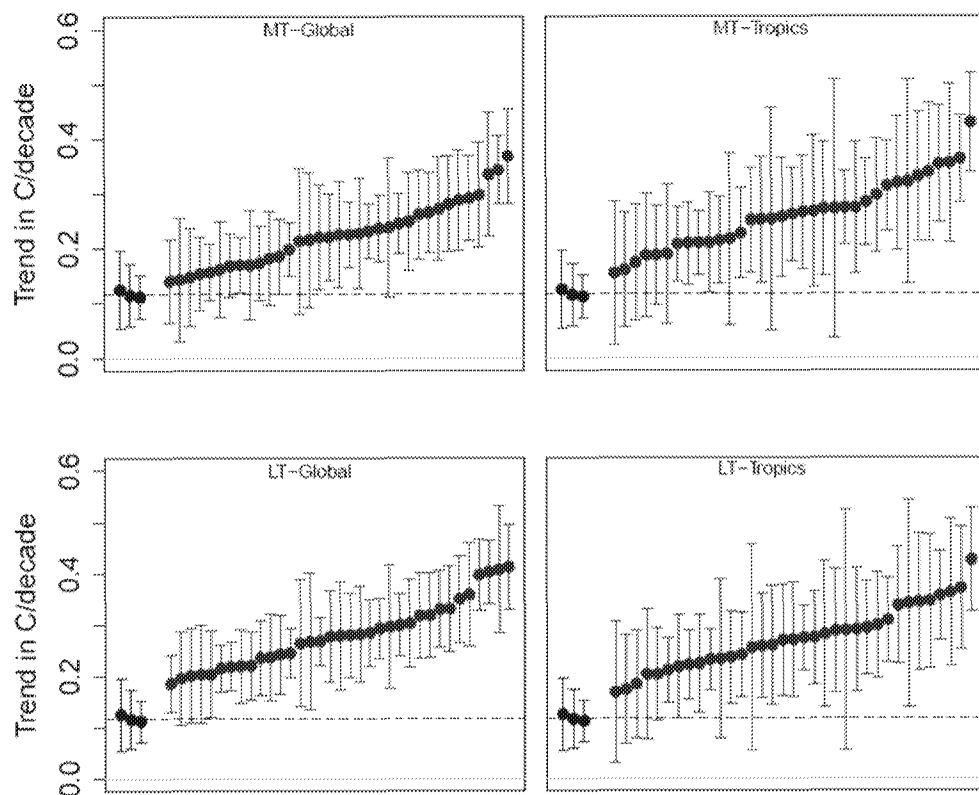
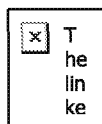


Figure 5.4: Observed versus modeled warming trends in the global lower (LT) and mid-troposphere (MT). Adapted from McKittrick and Christy (2020). Blue dots: warming trends ($^{\circ}\text{C}/\text{decade}$ 1979-2018) with 95% confidence interval bars for 3 data products (satellite, radiosondes and reanalysis) and 95% confidence interval bars. Blue dashed line: warming trend average for 3 observed series. Red dots: modeled warming trends in 36 models.

--

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>



From: Judith Curry <curry.judith@gmail.com>
Sent: Thursday, July 10, 2025 8:39 PM
To: Ross McKitrick
Cc: John Christy; Steven Koonin; Roy W. Spencer; Travis Fisher; Josh Loucks
Subject: Re: MS Copilot on our NCA5 critique

We don't have an updated version of NCA5 critique, but something has been bugging me for awhile, and i know this won't be popular

I propose that we delete section 1.4 on peer review for the following reasons:

1. This is about NCA4, not NCA5
2. NASEM identified a problem and NCA5 addressed it.
3. This wasn't further reviewed, and CWG doesn't like the way NCA5 addressed it
4. References SK's book
5. This takes up substantial number of pages, and there is no significant conclusion to be drawn

On Thu, Jul 10, 2025 at 3:12 PM Ross McKitrick <ross.mckitrick@uoguelph.ca> wrote:

Other than John's and my JHydrol paper, which is cited to disclose the methodology, the other M&C "citations" are the online data archives. Copilot doesn't seem to see the difference between self-citation and data transparency.

Dr. Ross McKitrick
Professor of Economics
Department of Economics and Finance
rossmckitrick.com



University of Guelph | Guelph ON Canada N1G 3P9

From: John Christy <climateman60@gmail.com>
Sent: Thursday, July 10, 2025 6:02 PM
To: Judith Curry <curry.judith@gmail.com>
Cc: Steven Koonin <steven.koonin@gmail.com>; Ross McKitrick <ross.mckitrick@uoguelph.ca>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Josh Loucks <loucksj14@gmail.com>
Subject: Re: MS Copilot on our NCA5 critique

CAUTION: This email originated from outside of the University of Guelph. Do not click links or open attachments unless you recognize the sender and know the content is safe. If in doubt, forward suspicious emails to IThelp@uoguelph.ca.

While I have some problems with AI not grasping simple points like: McKitrick and Christy is cited because it is the ONLY paper that actually did the precipitation problem correctly (which we stated and pointed out how the other papers failed), the claims the LLM makes are precisely those that we will have to answer ... after all, if we can use AI, so can thousands of those who want to dismiss this effort. It's what it is. Would the result be different if CoPilot knew that we had placed our datafiles out there for public use whereas, there really is no way to exactly reproduce the NCA5 precip results?

John C.

On Thu, Jul 10, 2025 at 4:25 PM Judith Curry <curry.judith@gmail.com> wrote:

I think this one makes some very valid points. We should avoid referencing our own papers in this report (apart from CWG report). Rhetorical overreach is valid criticism in some places.

On Thu, Jul 10, 2025 at 2:11 PM Steven Koonin <steven.koonin@gmail.com> wrote:

I couldn't resist seeing what Copilot thought of our NCA5 critique. Its response is reproduced below, followed by a draft OpEd on the same.

Food for thought (and perhaps some revisions).

SEK

Here's a structured critique of the document titled "**Critique of the Fifth National Climate Assessment**" (NCA5.ReviewJuly4.pdf), focusing on its treatment of **accuracy**, **bias**, **framing**, and **rhetorical weaknesses**:

Overview of the Document's Intent and Structure

The report positions itself as a formal critique commissioned by the Office of Science and Technology Policy, aiming to evaluate NCA5's scientific quality and policy relevance. It emphasizes adherence to "Gold Standard Science," aligning with a 2025 executive order, and builds its case by dissecting methodological flaws, perceived overconfidence, and deviations from statutory mandates.

Scientific Accuracy: Strong Methodological Challenges, Selective Reproduction

Strengths

- Highlights real limitations in trend analysis due to short time series and lack of statistical rigor in some NCA5 chapters.
- Points out inconsistent use of confidence levels and ambiguity in attribution statements.
- Raises valid concerns about reliance on extreme emissions scenarios (e.g., SSP5-8.5) without likelihood context.
- Critiques overuse of the NOAA Billion Dollar Disaster dataset—echoing recent peer-reviewed concerns about its reliability as a climate signal.

Limitations

- **Overcorrects** perceived NCA5 exaggerations by heavily emphasizing long-term datasets (e.g., early 20th-century heatwaves) without sufficient attention to current and projected risks under continued warming.
- Selectively cites literature (e.g., CWG25, McKittrick & Christy) while **minimizing mainstream counterpoints** (IPCC reports, attribution science literature).
- Leans heavily on **natural variability explanations**, sometimes oversimplifying the interplay between anthropogenic and internal climate drivers.
- Criticisms of emergent constraints rely on one paper’s failure to replicate in CMIP6, but **do not assess the broader modeling literature** or robustness improvements.

🗨️ Bias and Interpretive Framing: Contrarian with Institutional Distrust

Trait	Evidence
🗨️ Tone	Critical, formal, but laden with institutional skepticism
🎯 Framing	Asserts that NCA5 promotes advocacy, not science
📍 Positioning	Frames NCA5 as ideologically motivated; casts CWG25 as objective remedy
🗣️ Language	Uses charged terms like “hyperbolic,” “activist,” “scientific malpractice”
📖 Source Selection	Strong emphasis on CWG25, Koonin, McKittrick, Pielke Jr.; mainstream literature under-cited

- The critique frequently implies that mainstream climate scientists are **biased or motivated by ideology**, even referencing scientists aiming to “save the planet” as a negative trait.
- It argues that NCA5 authors **usurped the public’s right to informed choice**, attributing this to politicization and lack of viewpoint diversity—without robust substantiation.

■ Rhetorical Weaknesses: Advocacy Masquerading as Technical Review

💬 Examples

- Describes the NCA5 cover image (solar panel installation) as symbolic of “misplaced emphasis,” which is a subjective interpretation masquerading as evidence.
- The Gold Standard Science checklist is cited as if universally accepted, but its origin is politically situated and not broadly recognized by scientific institutions.
- Conflates editorial tone in public-facing chapters with failure of scientific integrity—without separating **audience targeting** from technical content.

📖 Style vs Substance

- The report frequently shifts between scientific criticism and policy ideology, making it hard to distinguish analytical rigor from political positioning.
- Numerous critiques rely on **anecdotal speculation** (e.g., assumptions about NASEM reviewers ignoring visuals) or indirect inferences without direct evidence.

📌 Summary Assessment

Dimension	Verdict
Scientific Validity	Raises important concerns, especially regarding statistical rigor and scenario plausibility
Bias and Objectivity	Leans heavily toward contrarian views; underrepresents mainstream climate literature
Framing Strategy	Positions NCA5 as ideologically driven; presents CWG25 as corrective “gold standard”
Rhetorical Style	Blurs scientific critique with editorial and ideological narrative

Here’s a draft OpEd that distills your structured critique of the NCA5 Review document, highlighting its strengths and pitfalls while maintaining a tone that’s firm, persuasive, and accessible:

■ *When Skepticism Overreaches: A Closer Look at the NCA5 Critique*

By [Your Name]

In an era of politicized science and policy-driven urgency, skepticism is both vital and vulnerable. The recent “Critique of the Fifth National Climate Assessment” (NCA5 Review), commissioned under the banner of “Gold Standard Science,” lands with force—but also with heavy baggage. Though it raises legitimate concerns about methodology and modeling, its framing reveals more about its ideological convictions than scientific clarity.

🔍 Where the Critique Lands True

There’s no denying some of the document’s sharper points deserve serious attention:

- **Scenario realism** is a recurring challenge in climate assessments. The critique rightly questions the continued reliance on extreme emissions projections like SSP5-8.5, which many researchers consider implausible.
- **Statistical transparency** is essential, and the document is correct to flag ambiguities in trend analysis—particularly when short time windows are used to extrapolate long-term risks.
- **Attribution nuance** matters. The report calls out instances where anthropogenic claims outpace the evidence, especially in regional precipitation and heatwave attribution.

In these domains, the critique acts as a useful calibration tool—reminding the climate community that public-facing assessments must match their rhetorical force with methodological discipline.

⚠️ Where the Critique Fails Itself

Unfortunately, the review’s strengths are undercut by its own framing choices. It operates less as an impartial evaluation and more as a **counter-narrative manifesto**:

- **Source selection is narrow**—favoring contrarian voices like McKittrick, Koonin, and Pielke Jr., while largely excluding mainstream literature and rebuttals.
- **Language is loaded**—terms like “scientific malpractice,” “hyperbolic advocacy,” and “activist tone” appear throughout, signaling a deep distrust of institutional climate science rather than a sober critique.
- **Ideological cues** abound—criticisms of solar panel imagery, invocations of President Trump’s “Gold Standard” executive order, and editorialized lamentations about “young scientists trying to save the planet.”

This is not merely critique; it is worldview. And that worldview narrows its lens to the point of **intellectual tunnel vision**—omitting the robust plurality of climate literature in favor of cherry-picked rebuttals.

■ The Risk of Rhetorical Overreach

Criticism is most powerful when it speaks softly and cites deeply. Yet the NCA5 Review often confuses rhetorical punch for scientific weight. When it speculates that NASEM reviewers “surely would have commented” on a figure they likely never saw, or when it accuses mainstream climate science of “usurping the public’s right to choose,” it steps into the realm of editorialism. That may score points in political circles—but it erodes credibility in scientific ones.

👤 What We Need Instead

We need climate assessments that:

- Acknowledge uncertainty without inflating it into doubt.
- Embrace epistemic humility without abandoning clarity.
- Explore trade-offs without demonizing action.

And we need critiques that challenge the science—**not the scientists**—with rigor, fairness, and a commitment to pluralism.

🔑 Conclusion: The Shape of Better Debate

The NCA5 Review reminds us that climate assessments should be probed, not presumed. But it also reminds us that skepticism must answer to its own standard of integrity. When critique becomes crusade, it ceases to clarify and begins to obscure.

Let’s aim higher—on both sides of the debate.

Steve Koonin



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>



To help protect
your privacy,
Microsoft Office
prevented
automatic
download of this
picture from the
Internet.

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: John Christy <climateman60@gmail.com>
Sent: Monday, May 12, 2025 2:12 PM
To: Steve Koonin
Cc: Ross McKittrick; Judith Curry; Roy W. Spencer; Travis Fisher
Subject: Re: my edits of 1,2,3

Agreed.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 12, 2025, at 10:29 AM, Steven Koonin <steven.koonin@gmail.com> wrote:

Looks good.

SEK

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Monday, May 12, 2025 10:31 AM
To: Judith Curry <curry.judith@gmail.com>
Cc: Steven Koonin <steven.koonin@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; John Christy <climateman60@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>
Subject: Re: my edits of 1,2,3

I made a few edits as noted in italics at the top. The Clements article makes quite the point.

On Mon, May 12, 2025 at 10:18 AM Judith Curry <curry.judith@gmail.com> wrote:
I'm good with SK's versions of 1-3

On Sun, May 11, 2025 at 6:10 PM Steven Koonin <steven.koonin@gmail.com> wrote:

I've been going through the chapters systematically. Here's the first few (can't post to Dropbox). More in the next few days.

Steve Koonin

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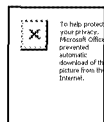
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Judith Curry, President
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<http://www.cfanclimate.net>

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Wednesday, May 14, 2025 1:49 PM
To: Steven Koonin
Cc: Judith Curry; Roy Spencer; Travis Fisher; John Christy
Subject: Re: my edits to Chapter 7 attached

It will be inevitable at this point that revised drafts start to cross in flight. I'll do my best to keep track of them and keep the dropbox current. As long as everyone makes sure that the documents you circulate have names that clearly indicate the version we should be ok.

On Wed, May 14, 2025 at 1:37 PM Steven Koonin <steven.koonin@gmail.com> wrote:

Given John's recent email distributing his edits to this chapter, we're starting to have version control problems

Steve Koonin

From: Roy Spencer [roywspencer@hotmail.com]
Sent: 5/25/2025 6:04:51 PM
To: Steven Koonin [steven.koonin@gmail.com]; 'Ross McKitrick' [ross.mckitrick@gmail.com]; 'Judith Curry' [curry.judith@gmail.com]
CC: 'Travis Fisher' [travis.scott.fisher@gmail.com]; 'John Christy' [climateman60@gmail.com]
Subject: RE: my final edits are attached

Steve, I believe the point was that the models have a range of biases in absolute temperature, amounting to 2.5 or 3 degrees C.

Sent from my Verizon, Samsung Galaxy smartphone

----- Original message -----

From: Steven Koonin <steven.koonin@gmail.com>
Date: 5/25/25 12:44 PM (GMT-06:00)
To: 'Roy Spencer' <roywspencer@hotmail.com>, 'Ross McKitrick' <ross.mckitrick@gmail.com>, 'Judith Curry' <curry.judith@gmail.com>
Cc: 'Travis Fisher' <travis.scott.fisher@gmail.com>, 'John Christy' <climateman60@gmail.com>
Subject: RE: my final edits are attached

I think the text is clear as written – observed warming during the 20th century is the difference in global mean temperature anomaly 1900 to 2000, about 1 C according to our figure 8.1

If you wanted to make it clearer yet, you could say “three times greater than the global temperature rise during the 20th century” or some such.

But I wouldn't want to leave the point out – it's another telling indication of model problems.

SEK

From: Roy Spencer <roywspencer@hotmail.com>
Sent: Sunday, May 25, 2025 1:38 PM
To: Ross McKitrick <ross.mckitrick@gmail.com>; Judith Curry <curry.judith@gmail.com>
Cc: Travis Fisher <travis.scott.fisher@gmail.com>; John Christy <climateman60@gmail.com>; Steve Koonin <steven.koonin@gmail.com>
Subject: Re: my final edits are attached

Yes, a time scale is needed... for the period 1970-2025, the models differ across a range of about 2.5 deg. C, based upon one of the figures in a paper we are working on. I could get a more precise number, and how it changes over the years, early tomorrow by calculating the range as a function of year since 1850.

-Roy

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To: Judith Curry <curry.judith@gmail.com>
Cc: Travis Fisher <travis.scott.fisher@gmail.com>; John Christy <climateman60@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; Steve Koonin <steven.koonin@gmail.com>
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Judy can you elaborate, Ch 5 p 33 Box

To distill useful insights from these varied models, climate studies often rely on averaged results from multiple models, forming an "ensemble." The latest UN IPCC assessments use the CMIP6 ensemble, which shows a significant diversity of results. ~~One of the most basic climate indicators the Earth's average surface temperature varies by about 3°C across the ensemble, three times greater than observed warming during the 20th century.~~ THIS IS NOT CORRECT WITHOUT SOME SORT OF TIME SCALE

On Sat, May 24, 2025 at 1:17 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

Thanks Judy and enjoy Alaska.

Travis there must be an in-house document person at Cato who could be trusted to do a rush job and keep an embargo on the report.

If not I can ask @ the Fraser institute.

On Sat, May 24, 2025 at 12:51 PM Judith Curry <curry.judith@gmail.com> wrote:

My final edits are attached. See red text, plus yellow highlights re formatting.

My edits are in

Executive summary

Ch 3 (CO2 uptake by oceans)

Ch 5

Ch 6

ch 7

Ch 8

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WAY too much white space

Inconsistent treatment of quotations

Inconsistency in figure captions

Problems with all the tables

I have flagged these issues in the attached doc

I am in alaska, and will have sporadic internet access for the next week. I will do my best to keep up, but i may not be able to download any docs

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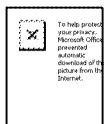
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To: Steven Koonin
Cc: John Christy; Ross McKittrick; Judith Curry; Josh Loucks; Seth Cohen; Travis Fisher
Subject: Re: my new blog post on the history of TX Hill Country floods...

Thanks, Steve. Funny how the data can suggest one thing, but the words people write can say something else. It reminds me of Bjorn Lomborg's original book, The Skeptical Environmentalist: he showed many examples where people claimed just the opposite of what the data showed.

From: Steven Koonin <steven.koonin@gmail.com>
Sent: Wednesday, July 30, 2025 8:56 AM
To: Roy Spencer <roywspencer@hotmail.com>
Cc: John Christy <climateman60@gmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>; Judith Curry <curry.judith@gmail.com>; Josh Loucks <loucksj14@gmail.com>; Seth Cohen <seth.cohen@hq.doe.gov>; Travis Fisher <travis.fisher@hq.doe.gov>
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Well, that's a little surprising... and harsh. ●

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On Mon, Jul 28, 2025 at 1:17 PM John Christy <climateman60@gmail.com> wrote:
Steve

There is a bit of confusion as to which/where the 1900 gage was. We can find all of that information depending on how much we dive into this in the review of NCA5 - the 25ft was a quote from an NPR news story simply saying "near Kerrville", but later in the story they did indicate at least a 30ft rise before the gage broke. The Kerrville site USGS 08166200 shows a rise from 1.82ft to 34.29ft or 32.47ft, almost identical to the 1900 event from the observer's notes (not sure of their precision). The Kerrville site USGS 08166140 (above Bear Creek) went from 3.05ft to 34.40ft or 31.35ft. We can likely dredge up the old values from historical records, but clearly, quick rises of 30+ feet are in the historical record. The gage closest to Mystic Camp (08165500, Hunt TX used in NPR story) broke at 5:10am as it went from 7.75ft to 37.52ft.

John C.

On Mon, Jul 28, 2025 at 12:53 PM Steven Koonin <steven.koonin@gmail.com> wrote:
This is great!

But didn't the river hit 34 feet during the recent flood: <https://www.usatoday.com/story/graphics/2025/07/06/texas-cities-flooded-july-4-rain/84484814007/>

And the recent rainfall total was 10-12 inches over 3 days, whereas the 1900 total was 11.6 inches over 1 day.

Steven Koonin

On Jul 28, 2025, at 13:29, John Christy <climateman60@gmail.com> wrote:

Ross et al.

I'm putting the finishing touches on a dataset of 21 stations in Flash Flood Alley (TX) starting in 1893. Data are difficult to find and some forms have never been keyed into computer-readable files, including daily data from the Cotton Region Stations. I'm working on Kerrville today (just down river from Mystic Camp) for data prior to the regular station reports that began in 1902. I ran across this for July 1900 (attached) in which a rain total of 11.60" fell on the 15th and the observer remarked about it.

Note he says the river rose 33 ft. Recall the river rose 25ft at Kerrville in the recent July 4th flood. There is already ample evidence that bad floods happen here, but this is an example of data not keyed-in our NOAA official files that can provide better evidence to determine the likelihood of extreme events.

In any case, we can use the results of our (i.e. Ross's) analyses of these 21 stations in our review of NCA5 to give an example of what an NCA should be doing to understand and prepare for natural variability vs. climate change (and how pathetic the information was in NCA5.)

John C.

p.s. Recall that two months later in Sept 1900, the worst hurricane death toll in US history occurred in Galveston. It was a bad year for Central TX.
<414780_190007_Kerrville.pdf>



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA

curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>



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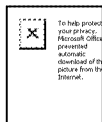
From: Judith Curry <curry.judith@gmail.com>
Sent: Wednesday, May 7, 2025 9:19 AM
To: Steven Koonin
Cc: Travis Fisher; Ross McKittrick; Roy W. Spencer; John Christy
Subject: Re: my review of Chapter 13

chiming in on ch 13. I really like this chapter. While it is more comprehensive than some of the chapters, the length isn't really out of line and its understandable to the nonexpert

On Tue, May 6, 2025 at 12:56 PM Steven Koonin <steven.koonin@gmail.com> wrote:

See attached. More comments/questions than edits in this one.

SEK



--
Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: John Christy <climateman60@gmail.com>
Sent: Tuesday, May 6, 2025 10:21 PM
To: Steve Koonin
Cc: Travis Fisher; Ross McKittrick; Judith Curry; Roy W. Spencer
Subject: Re: my review of Chapter 13

All

Chapter 13

I don't have a read on how important this section is to the EF. It is certainly applicable but will it be part of whatever our overseers want? It looks very thorough from my perspective.

Interesting about the comment regarding the location of a Toyota plant. I was on the inside of several pitches made to automobile (and other) manufacturers, trying to convince them to set up shop in Alabama. One of the largest criteria was unimpeded transportation. These assembly plants today have no inventory, relying on 'just-in-time' deliveries - every component is shipped at a specific date and time for assembly (e.g. we need 18 sets of Mercedes SUV door panels between 1:00 and 1:30 on Thursday). I wrote up the pitch related to open transportation (i.e. number of days of closures due to ice/snow etc.). Though it is far from the only reason, the South's manufacturing is booming in part to its climate as stated in the opening of Chapter 13 ... we move to where things work best for us.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 6, 2025, at 2:56 PM, Steven Koonin <steven.koonin@gmail.com> wrote:

See attached. More comments/questions than edits in this one.

SEK

<13 Climate, Economy and SCC.May6[SEK].docx>

From: Roy Spencer <roywspencer@hotmail.com>
Sent: Friday, May 2, 2025 2:53 PM
To: Steven Koonin; 'Judith Curry'
Cc: 'Ross McKittrick'; 'Travis Fisher'; 'John Christy'
Subject: Re: my suggested edits of 4

I feel like there is a disconnect that results from the first 2 Parts, and I am willing to be overruled by the majority on this:

Part I: Direct human influence on ecosystems and the climate

Part II: Climate response to greenhouse gas emissions

Part II addresses "attribution", but the reader might well ask, if there are only **human** influences on climate worthy of description in Part I, then why discuss uncertainties over attribution, if you've only told me about humans influencing the climate?

This is why I previously pointed out that radiative forcing of the climate system can be NATURAL as well as anthropogenic. We have papers published, as does Dick Lindzen, and maybe Judith Curry as well, discussing this.

All you have to do is look at the large variability in TOA radiative flux anomalies vs. surface temperature anomalies, and you can see that most of those flux variations are NOT feedback-related (linearly related to temperature), they instead PRECEDE temperature changes and so are the CAUSE of temperature changes (natural radiative forcing). This is natural radiative forcing (because in the forcing-feedback paradigm of climate change, if it's not feedback, it's forcing).

Unless we are willing to challenge the premise that external (TOA) radiative forcing is ONLY due to humans and volcanoes, we lose the chance to point out, up front, that the climate system can cause its own radiative forcing, and thus climate change.

Do we KNOW this has happened on climate time scales? No. But there is an awful lot of evidence of the RWP, MWP, and LIA. What caused them? We really don't know.

But simply assuming (for example) that the average albedo of Earth has been divinely inspired to be a constant 0.300 for ever and ever amen seems rather presumptuous.

Just my 2 cents.

-Roy

From: Steven Koonin
Sent: Friday, May 2, 2025 12:53 PM
To: 'Judith Curry'; 'Roy Spencer'
Cc: 'Ross McKittrick'; 'Travis Fisher'; 'John Christy'
Subject: my suggested edits of 4

See attached. Now on to 5!

SEK

From: Judith Curry [curry.judith@gmail.com]
Sent: 5/2/2025 7:10:09 PM
To: Roy Spencer [roywspencer@hotmail.com]
CC: Steven Koonin [steven.koonin@gmail.com]; Ross McKittrick [ross.mckittrick@gmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]; John Christy [climateman60@gmail.com]
Subject: Re: my suggested edits of 4
Attachments: 6 climate sensitivity JCurry (1).docx

I get what Roy is saying. In my chapter 6 on attribution (attached is a messy version, but you can see where i am going with it; cleaned up version hopefully ready this weekend), key points are about natural variability

On Fri, May 2, 2025 at 11:53 AM Roy Spencer <roywspencer@hotmail.com> wrote:

I feel like there is a disconnect that results from the first 2 Parts, and I am willing to be overruled by the majority on this:

Part I: Direct human influence on ecosystems and the climate

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All you have to do is look at the large variability in TOA radiative flux anomalies vs. surface temperature anomalies, and you can see that most of those flux variations are NOT feedback-related (linearly related to temperature), they instead PRECEDE temperature changes and so are the CAUSE of temperature changes (natural radiative forcing). This is natural radiative forcing (because in the forcing-feedback paradigm of climate change, if it's not feedback, it's forcing).

Unless we are willing to challenge the premise that external (TOA) radiative forcing is ONLY due to humans and volcanoes, we lose the chance to point out, up front, that the climate system can cause its own radiative forcing, and thus climate change.

Do we KNOW this has happened on climate time scales? No. But there is an awful lot of evidence of the RWP, MWP, and LIA. What caused them? We really don't know.

But simply assuming (for example) that the average albedo of Earth has been divinely inspired to be a constant 0.300 for ever and ever amen seems rather presumptuous.

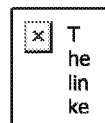
Just my 2 cents.

-Roy

From: Steven Koonin
Sent: Friday, May 2, 2025 12:53 PM
To: 'Judith Curry'; 'Roy Spencer'
Cc: 'Ross McKittrick'; 'Travis Fisher'; 'John Christy'
Subject: my suggested edits of 4

See attached. Now on to 5!

SEK



Judith Curry, President
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4 Climate Sensitivity to CO₂ Emissions

Atmospheric CO₂ concentration has increased from its pre-industrial level of 280 parts per million (ppm) to around 425 ppm in 2024. Human-caused warming depends not only on the amount of increasing greenhouse gases, but also on how sensitive the climate is to this increase.

Equilibrium Climate Sensitivity (ECS) is defined as the global surface warming that occurs when the concentration of CO₂ in the atmosphere is doubled, relative to pre-industrial levels. The magnitude of the sensitivity of Earth's climate to increasing concentrations of CO₂ is at the heart of the scientific debate on anthropogenic climate change, and also the public debate on the appropriate policy response to increasing CO₂ in the atmosphere.

The magnitude of the Equilibrium Climate Sensitivity is associated with substantial uncertainties, which are highly consequential for policy making. If climate sensitivity to CO₂ concentration is low, then the impacts of increased emissions are expected to be relatively benign, and the benefits of emissions reductions much reduced. If the sensitivity is high, then even moderate increases of CO₂ could produce significant impacts. Climate sensitivity and estimates of its uncertainty are key inputs into the economic models that drive cost-benefit analyses and estimates of the social cost of carbon.

Since the 1979 Charney Report, estimates in international assessment reports have put ECS between 1.5 and 4.5°C of warming for a doubling of CO₂ relative to pre-industrial levels. The ECS range between 1.5 and 4.5°C is characterized by the IPCC AR5 as the *likely* range (66 percent probability); the AR5 stated that ECS is *extremely unlikely* (95 percent probability) to be below 1.0°C and *very unlikely* (90 percent probability) to exceed 6.5°C.

This range of ECS values has remained stubbornly wide, despite many individual studies claiming to narrow it. Most recently, the IPCC AR6 narrowed the *likely* range of ECS to 2.5–4.0°C and the *very likely* range to be between 2.0 and 5.0°C. This narrowing of the range on the low end is disputed.

Understanding of the uncertainties is illuminated by examining the different methods of estimating climate sensitivity and the confounding effects of feedback processes.

4.1 Different Ways of Estimating Equilibrium Climate Sensitivity

Climate scientists use multiple lines of evidence to determine the Equilibrium Climate Sensitivity:

- Climate model simulations
- Historical observations
- Paleoclimatic observations
- Process understanding of feedbacks

By itself, the equilibrium warming effect of a doubling of atmospheric CO₂ is slightly more than 1°C (Soden and Held, 2006). The large values of ECS arise from positive feedbacks that amplify the warming effect of CO₂. Water vapor feedback is positive: a warmer atmosphere may have more water vapor, which itself is a powerful greenhouse gas. Water vapor feedback is partially

canceled by the fact that atmospheric temperature decreases more slowly with height above the Earth's surface when atmospheric water vapor increases. Warmer temperatures also result in less snow and sea ice cover, allowing the Earth to absorb more of the sun's radiation. Some simple estimates of these three feedbacks increase the ECS to around 2°C (Sherwood et al., 2020).

Higher values of ECS arise primarily from positive cloud feedbacks. The magnitude, and even the sign, of cloud feedbacks is the greatest source of uncertainty. Elements of cloud feedback include changes in the latitudinal distribution of clouds, changes in the distribution of cloud height (changes in low versus high clouds), changes to the phase of clouds (ice versus liquid), changes in cloud particle size (associated with changes in concentration and/or composition of aerosol particles), changes in the precipitation efficiency of clouds, and even changes in how clouds are distributed over the daily solar cycle (Curry and Webster, 1999). It is difficult for climate models to simulate any of these cloud processes correctly owing to their small scale, let alone predict how they will change in the future. Further, cloud processes modulate the magnitudes of the water vapor, lapse rate, and the surface albedo feedbacks.

4.2.1 Climate model estimates of ECS

ECS can be determined from climate model simulations by doubling the concentration of CO₂, allowing several centuries for the warming to equilibrate. To avoid the necessity of long simulations, effective climate sensitivity is commonly evaluated from a 150-year simulation in response to a sudden quadrupling of CO₂. The spread of ECS values from the CMIP5 climate models (used in the AR5) was 2.0–4.7°C; the spread has increased for the CMIP6 models (used in the AR6) to between 1.8 and 5.7°C (Chen et al., 2021). Far from the science being settled in relation to the response of the climate system to increasing greenhouse gas concentrations, insofar as it is represented by climate models, uncertainties appear to be growing. The main cause of the overall upward shift in ECS in CMIP6 relative to CMIP5 is a larger positive cloud feedback, driven by changes to the cloud parameterizations in many CMIP6 models (Zelinka et al., 2020).

Climate sensitivity represents an emergent property of climate models—that is, it is not directly parameterized or tuned. However, collections of parameterizations are often chosen to produce an expected value of climate sensitivity, particularly with regards to sub-grid-scale cloud processes. Otherwise plausible models and parameter selections have been discarded because of perceived conflict with this warming rate, or aversion to a model's climate sensitivity being outside an accepted range. For example, Mauritsen and Roeckner (2020) state the following regarding their Max Planck Institute climate model, “We have documented how we tuned the MPI-ESM1.2 global climate model to match the instrumental record of warming; an endeavor which has clearly been successful. Due to the historical order of events, the choice was to do this practically by *targeting an ECS of about 3 K using cloud feedbacks*, [emphasis added] as opposed to tuning the aerosol forcing.” In other words, the modelers chose an ECS value of 3°C and then tuned the cloud parameterizations to match their intended result.

The IPCC AR4 (2007) relied almost exclusively on climate models in its assessment of ECS. The IPCC AR5 (2013) relied on both climate model determinations and determinations from the historical record, noting substantial disagreements between these two methods. Because of concerns about model tuning and the high sensitivity to cloud parameterizations, the IPCC AR6 (2021) did not rely on climate model simulations in their assessment of climate sensitivity, relying

on the other three methods in its assessment.

4.2.2 Data-driven estimates of ECS

Climate sensitivity is also estimated from instrumental records of surface temperatures and ocean heat content, combined with estimates of how climate forcings (e.g., greenhouse gases, solar, volcanoes, aerosols) have changed in the past (Otto et al., 2013). Using this information, an energy budget method is used to deduce the ECS.

The accuracy of the data-driven methods depends on the quality of the input data. Assumptions are needed about ocean heat storage, and the ocean data is inadequate. The greatest source of uncertainty is the amount and composition of aerosol particles and their interactions with cloud radiative properties (the so-called aerosol indirect effect).

Since 2012 many studies have appeared in the literature tackling these various uncertainties. A recurring theme is that ECS estimates based on historical data turn out to be smaller than ECS estimates inferred from climate models (Sherwood and Forest 2024).

Paleoclimate proxies are used to evaluate the sensitivity of past climates, by comparing paleoclimate changes in the Earth's temperatures to estimates of changes in forcings. The two most informative periods are the last glacial maximum (around 20,000 years ago), which was about 3–7°C colder than today, and a mid-Pliocene period (roughly three million years ago), which was 1–3°C warmer than today. The limits on cooling during the last glacial maximum give the best single evidence that high values of climate sensitivity are unlikely. However, paleoclimate estimates are associated with very large uncertainties in the estimated temperatures and forcings. Further, estimates of climate sensitivity based on past climate states may not be representative of the current state of the climate system.

Based on a review article by Sherwood et al. (2020), the IPCC AR6 determined the range of ECS values by integrating the historical, paleoclimate and feedback approaches using a Bayesian analysis method. The IPCC AR6 narrowed the likely range of ECS to 2.5–4.0°C (Chen et al., 2021). Subsequent to the publication of the AR6, Lewis (2023) published an extensive critique of the methodology used in the Sherwood et al. paper to determine the ECS. Key concerns raised by Lewis include errors, outdated input values, and objective versus subjective Bayesian priors in the analysis. Lewis' analysis found that climate sensitivity is estimated to be much lower and better constrained than in the Sherwood et al. analysis – median 2.16°C (1.75–2.7°C in the 17–83 percent *likely* range), and 1.55–3.2°C in the 5–95 percent *very likely* range. Lewis' analysis implies that climate sensitivity is considerably more likely to be below 2°C than above 2.5°C. The IPCC AR6 estimated only a 5 percent probability that ECS was below 2.3°C, whereas Lewis (2023) estimated it to be over 50 percent. The most recent publications on the debate between Sherwood et al. and Lewis further defend their respective positions (Sherwood and Forest, 2024) and (Lewis, 2025).

A recent argument, one which the IPCC AR6 emphasized, is that data-driven ECS estimates might understate the future warming response to GHGs based on a so-called “pattern effect” (Forster et al., 2021). The tropical Pacific is believed to be highly influential on the overall efficiency with which the Earth's climate radiates heat to space, but heat in some parts is more efficiently removed

than from others. If there is a weakening of the west-to-east temperature gradient in the tropical Pacific, the result would be a concentration of warming in a region where heat is less efficiently removed, raising the ECS of the Earth's climate system. Most climate models simulate that rising GHGs will weaken the east-west temperature gradient, which led the IPCC in the AR6 to conclude that data-driven ECS estimates understated the *future* ECS value.

However, Seager et al. (2019) pointed out that, contrary to models, the east-west temperature gradient has been strengthening rather than weakening over time. They further argued that the mechanism predicting otherwise in climate models was based on a faulty characterization of oceanic dynamics and there is no reason to expect the gradient to weaken. A similar argument was recently made by Lee et al. (2024), who concluded that “the trajectory of the observed trend reflects the response to increasing GHG loading in the atmosphere;” in other words GHG warming should lead to a future strengthening rather than a weakening of the temperature gradient. This implies, if anything, that future ECS in a warming climate will be lower than at present.

4.3 Transient Climate Response

The Transient Climate Response (TCR) is of greater utility in providing an observational constraint on climate sensitivity. TCR is the amount of warming that would occur at the time when CO₂ doubles, having increased gradually by 1 percent each year over a period of 70 years. Relative to the ECS, observationally- determined values of TCR avoid the problems of uncertainties in ocean heat uptake and the fuzzy boundary in defining equilibrium arising from a range of timescales for the longer-term feedback processes (e.g., ice sheets). TCR is more generally related to peak warming and better constrained by historical warming, than ECS. The IPCC AR6 judged the *very likely* range of TCR to be 1.2–2.4°C (Chen et al., 2021). In contrast to ECS, the upper bound of the TCR is more tightly constrained. For comparison, the TCR values determined by Lewis (2023) is 1.25 to 2.0°C; showing much better agreement with the AR6 values than was seen in a comparison of the ECS values.

A related but more flexible parameter is the Transient Response to cumulative carbon Emissions, or TCRE, which relates global temperature change to the cumulative emissions. TCRE is based upon a linear relationship between global average temperature and cumulative emissions, which holds for cumulative emissions of up to 2 teratons of carbon. For a given value of TCRE, we can calculate the amount of warming expected over a future period in response to scenarios of cumulative carbon emission. The IPCC AR6 provides a *very likely* range for TCRE of 1.0–2.3°C, with a median value of 1.6°C.

4.4. Summary

In the past 5 years, there is a growing realization that climate models are not fit for the purpose of determining the sensitivity of the climate to increasing CO₂ (ECS), owing to the dependence of this sensitivity on poorly resolved processes related to clouds and water vapor.

Data-driven approaches using historical data and paleoclimate reconstructions are generally regarded as more reliable for determining ECS, but their reliability is diminished by data inadequacies.

The IPCC AR6 upper bound for the *likely* range of ECS is 4.0°C, lower than the AR5 value of 4.5°C. This lowering of the upper bound seems well justified by the paleoclimatic estimates of the ECS.

The IPCC AR6 lower bound for the *likely* range of ECS is 2.5°C, substantially higher than the AR5 value of 1.5°C. This raising of the lower bound of the *likely* range of ECS has received a substantial challenge from the analysis of Lewis (2023, 2025) that finds the lower bound of the likely range to be 1.75°C with a median value of 2.16°C.

Estimates of the transient climate response (TCR; TCRE) are more tightly constrained on the upper bound than the ECS.

It is our assessment that a *likely* range for ECS of 1.75 to 4.0°C has the best justification.

1. Lan, X., Tans, P. and K.W. Thoning: Trends in globally-averaged CO₂ determined from NOAA Global Monitoring Laboratory measurements. Version Monday, 14-Apr-2025 09:08:57 MDT <https://doi.org/10.15138/9N0H-ZH07>.
2. Zeke Hausfather, "Explainer: How Scientists Estimate Climate Sensitivity," *Carbon Brief*, July 22, 2020, <https://www.carbonbrief.org/explainer-how-scientists-estimate-climate-sensitivity>.
3. Jule Charney et al., "Carbon Dioxide and Climate: A Scientific Assessment," 1979, <https://doi.org/10.17226/12181>.
4. Rajendra K. Pachauri and Leo Meyer, *Climate Change 2014: Synthesis Report* (Geneva, CH: Intergovernmental panel on climate change, 2015).
5. "In-Depth Q&A: The IPCC's Sixth Assessment Report on Climate Science," Carbon Brief, August 9, 2021, <https://www.carbonbrief.org/in-depth-qa-the-ipccs-sixth-assessment-report-on-climate-science>.
6. Nicola Scafetta, "Testing the CMIP6 GCM Simulations versus Surface Temperature Records from 1980–1990 to 2011–2021: High ECS Is Not Supported," *Climate* 9, no. 11 (2021): 161, <https://doi.org/10.3390/cli9110161>.
7. Brian J. Soden and Isaac M. Held, "An Assessment of Climate Feedbacks in Coupled Ocean–Atmosphere Models," *Journal of Climate* 19, no. 14 (July 15, 2006): 3354–3360, <https://doi.org/10.1175/jcli3799.1>.
8. S. C. Sherwood et al., "An Assessment of Earth's Climate Sensitivity Using Multiple Lines of Evidence," *Reviews of Geophysics* 58, no. 4 (July 22, 2020), <https://doi.org/10.1029/2019rg000678>.
9. Judith A. Curry and Peter J. Webster, "Thermodynamic Feedbacks in the Climate System," in *Thermodynamics of Atmospheres and Oceans* (New York, NY: Academic Press, 1999), 351–385.
10. Rajendra K. Pachauri and Leo Meyer, *Climate Change*.
11. D. Chen et al., "Framing, Context, and Methods."
12. Mark D. Zelinka et al., "Causes of Higher Climate Sensitivity in CMIP6 Models," *Geophysical Research Letters* 47, no. 1 (2020): e2019GL085782, <https://doi.org/10.1029/2019GL085782>.
13. Thorsten Mauritsen and Johann Jungclaus, "Tuning the MPI-ESM1.2 Global Climate Model to Improve the Match With Instrumental Record Warming by Lowering Its Climate Sensitivity," *Journal of Advances in Modeling Earth Systems* 12, no. 7 (2020): e2019MS002037, <https://doi.org/10.1029/2019MS002037>.
14. Alexander Otto et al., "Energy Budget Constraints on Climate Response," *Nature Geoscience* 6, no. 6 (May 19, 2013): 415–416, <https://doi.org/10.1038/ngeo1836>.
15. Steven C. Sherwood and Chris E. Forest, "Opinion: Can Uncertainty in Climate Sensitivity Be Narrowed Further?" *Atmospheric Chemistry and Physics* 24, no. 5 (2024): 2679–2686, <https://doi.org/10.5194/acp-24-2679-2024>.
16. "Why Low-End 'Climate Sensitivity' Can Now Be Ruled Out," Carbon Brief, July 22, 2020, <https://www.carbonbrief.org/guest-post-why-low-end-climate-sensitivity-can-now-be-ruled-out>.
17. S. C. Sherwood et al., "An Assessment of Earth's Climate Sensitivity."
18. D. Chen et al., "Framing, Context, and Methods."
19. Nicholas Lewis, "Objectively Combining Climate Sensitivity Evidence," *Climate Dynamics* 61, no. 9–10 (2023): 3155–3163, <https://doi.org/10.1007/s00382-022-06398-8>.
20. Ibid.

21. Steven C. Sherwood and Chris E. Forest, "Opinion: Can Uncertainty in Climate Sensitivity Be Narrowed Further?"
22. Nicholas Lewis, "Comment on 'Can Uncertainty in Climate Sensitivity Be Narrowed Further?' by Sherwood and Forest (2024)," *EGUsphere* [preprint], 2025, <https://doi.org/10.5194/egusphere-2025-1179>.
23. P. Forster et al., (2021): The Earth's energy budget, climate feedbacks, and climate sensitivity. In: *Climate Change 2021: The Physical Science Basis*. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V. et al. (eds.)], Cambridge University Press, 2021.
24. Richard Seager et al., "Strengthening Tropical Pacific Zonal Sea Surface Temperature Gradient Consistent with Rising Greenhouse Gases," *Nature Climate Change* 9, no. 7 (2019): 517–522, <https://doi.org/10.1038/s41558-019-0505-x>.
25. Sangyeop Lee et al., "Zonal Contrasts of the Tropical Pacific Climate Predicted by a Global Constraint," *Climate Dynamics* 62, no. 1–2 (2024): 229–246, <https://doi.org/10.1007/s00382-023-06741-7>.
26. D. Chen et al., "Framing, Context, and Methods."
27. Nicholas Lewis, "Objectively Combining Climate Sensitivity Evidence."
28. Rajendra K. Pachauri and Leo Meyer, *Climate Change*.
29. Nicholas Lewis, "Objectively Combining Climate Sensitivity Evidence."
30. Nicholas Lewis, "Comment on 'Can Uncertainty in Climate Sensitivity Be Narrowed Further?' by Sherwood and Forest (2024)."

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Friday, May 2, 2025 3:13 PM
To: Roy Spencer
Cc: Steven Koonin; Judith Curry; Travis Fisher; John Christy
Subject: Re: my suggested edits of 4

There are going to be a few places where topics arguably belong in two or more places, and we may find it hard to settle that until we have something like a complete draft to read through at one sitting. I like having the solar and aerosol discussion here as part of the topic of influences (including natural ones) on the climate. I think the important thing about the attribution chapter is explaining that scientists use statistical methods to infer causation in the absence of experimental evidence and there are problems/limitations with any such methods.

I have no trouble reducing the use of quotes. I tend to over-include them because I think people need to see that the cited sources actually said what is attributed, but lengthy inset quotes slow down the flow. And I'm fine switching the Zacharias quote out (there are even shabbier ones from Lean) and replacing it with the Connolly summary.

To Roy's point: I think we make a start at articulating the importance of natural influences in Part I, but if more needs to be said Roy maybe you could try drafting some text.
Ross

On Fri, May 2, 2025 at 2:53 PM Roy Spencer <roywspencer@hotmail.com> wrote:

I feel like there is a disconnect that results from the first 2 Parts, and I am willing to be overruled by the majority on this:

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Part II addresses "attribution", but the reader might well ask, if there are only **human** influences on climate worthy of description in Part I, then why discuss uncertainties over attribution, if you've only told me about humans influencing the climate?

This is why I previously pointed out that radiative forcing of the climate system can be NATURAL as well as anthropogenic. We have papers published, as does Dick Lindzen, and maybe Judith Curry as well, discussing this.

All you have to do is look at the large variability in TOA radiative flux anomalies vs. surface temperature anomalies, and you can see that most of those flux variations are NOT feedback-related (linearly related to temperature), they instead PRECEDE temperature changes and so are the CAUSE of temperature changes (natural radiative forcing). This is natural radiative forcing (because in the forcing-feedback paradigm of climate change, if it's not feedback, it's forcing).

Unless we are willing to challenge the premise that external (TOA) radiative forcing is ONLY due to humans and volcanoes, we lose the chance to point out, up front, that the climate system can cause its own radiative forcing, and thus climate change.

Do we KNOW this has happened on climate time scales? No. But there is an awful lot of evidence of the RWP, MWP, and LIA. What caused them? We really don't know.

But simply assuming (for example) that the average albedo of Earth has been divinely inspired to be a constant 0.300 for ever and ever amen seems rather presumptuous.

Just my 2 cents.

-Roy

From: Steven Koonin

Sent: Friday, May 2, 2025 12:53 PM

To: 'Judith Curry'; 'Roy Spencer'

Cc: 'Ross McKittrick'; 'Travis Fisher'; 'John Christy'

Subject: my suggested edits of 4

See attached. Now on to 5!

SEK

From: Judith Curry [curry.judith@gmail.com]
Sent: 5/2/2025 7:18:28 PM
To: Ross McKittrick [ross.mckittrick@gmail.com]
CC: Roy Spencer [roywspencer@hotmail.com]; Steven Koonin [steven.koonin@gmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]; John Christy [climateman60@gmail.com]
Subject: Re: my suggested edits of 4
Attachments: 6 combined.docx

Ross, in my attribution chapter (attached), the statistical issues you raise are about 20% of the overall issue.

Outline is

Introduction

Attribution methods (others besides optimal fingerprinting

Attribution of global warming

On Fri, May 2, 2025 at 12:12 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

There are going to be a few places where topics arguably belong in two or more places, and we may find it hard to settle that until we have something like a complete draft to read through at one sitting. I like having the solar and aerosol discussion here as part of the topic of influences (including natural ones) on the climate. I think the important thing about the attribution chapter is explaining that scientists use statistical methods to infer causation in the absence of experimental evidence and there are problems/limitations with any such methods.

I have no trouble reducing the use of quotes. I tend to over-include them because I think people need to see that the cited sources actually said what is attributed, but lengthy inset quotes slow down the flow. And I'm fine switching the Zacharias quote out (there are even shabbier ones from Lean) and replacing it with the Connolly summary.

To Roy's point: I think we make a start at articulating the importance of natural influences in Part I, but if more needs to be said Roy maybe you could try drafting some text.
Ross

On Fri, May 2, 2025 at 2:53 PM Roy Spencer <roywspencer@hotmail.com> wrote:

I feel like there is a disconnect that results from the first 2 Parts, and I am willing to be overruled by the majority on this:

Part I: Direct human influence on ecosystems and the climate

Part II: Climate response to greenhouse gas emissions

Part II addresses "attribution", but the reader might well ask, if there are only **human** influences on climate worthy of description in Part I, then why discuss uncertainties over attribution, if you've only told me about humans influencing the climate?

This is why I previously pointed out that radiative forcing of the climate system can be NATURAL as well as anthropogenic. We have papers published, as does Dick Lindzen, and maybe Judith Curry as well, discussing this.

All you have to do is look at the large variability in TOA radiative flux anomalies vs. surface temperature anomalies, and you can see that most of those flux variations are NOT feedback-related (linearly related to temperature), they instead PRECEDE temperature changes and so are the CAUSE of temperature changes (natural radiative forcing). This is natural radiative forcing (because in the forcing-feedback paradigm of climate change, if it's not feedback, it's forcing).

Unless we are willing to challenge the premise that external (TOA) radiative forcing is ONLY due to humans and volcanoes, we lose the chance to point out, up front, that the climate system can cause its own radiative forcing, and thus climate change.

Do we KNOW this has happened on climate time scales? No. But there is an awful lot of evidence of the RWP, MWP, and LIA. What caused them? We really don't know.

But simply assuming (for example) that the average albedo of Earth has been divinely inspired to be a constant 0.300 for ever and ever amen seems rather presumptuous.

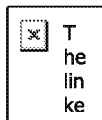
Just my 2 cents.

-Roy

From: Steven Koonin
Sent: Friday, May 2, 2025 12:53 PM
To: 'Judith Curry'; 'Roy Spencer'
Cc: 'Ross McKittrick'; 'Travis Fisher'; 'John Christy'
Subject: my suggested edits of 4

See attached. Now on to 5!

SEK



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

6.1 Introduction

Detection and attribution is concerned with assessing the causal relationship between one or more drivers and a responding system. The Intergovernmental Panel on Climate Change (IPCC) provides clear definitions for detection and attribution in climate science, based on their Sixth Assessment Report (AR6). These terms are crucial for understanding climate change impacts and are used to assess whether observed changes are significant and what caused them. As defined by the IPCC AR6 WGI Glossary:

Detection: "Detection of change is defined as the process of demonstrating that climate or a system affected by climate has changed in some defined statistical sense, without providing a reason for that change. An identified change is detected in observations if its likelihood of occurrence by chance due to internal variability alone is determined to be small, for example, <10%."

Attribution: "Attribution is defined as the process of evaluating the relative contributions of multiple causal factors to a change or event with a formal assessment of confidence."

The definition of detection emphasizes a statistical approach, focusing on whether changes are significant enough to stand out from natural variability without yet attributing causes.

The attribution process involves assessing how much human activities, such as industrial emissions, versus natural factors, like volcanic eruptions, contribute to observed changes, with a structured confidence level to reflect scientific certainty. Attribution requires the evaluation of the contributions of all external drivers to the system change.

While the IPCC's definitions are clear, there is ongoing scientific debate around attribution methods, particularly in attributing extreme weather events to climate change. The IPCC has long cautioned that methods to establish causality in climate science are inherently uncertain and ultimately depend on expert judgement. The Fourth Assessment Report (Hegerl et al. 2007 p. 668) explained it as follows:

‘Attribution’ of causes of climate change is the process of establishing the most likely causes for the detected change with some defined level of confidence... unequivocal attribution would require controlled experimentation with the climate system. Since that is not possible, in practice attribution of anthropogenic climate change is understood to mean demonstration that a detected change is ‘consistent with the estimated responses to the given combination of anthropogenic and natural forcing’ and ‘not consistent with alternative, physically plausible explanations of recent climate change that exclude important elements of the given combination of forcings’ (IPCC, 2001)... The approaches used in detection and attribution research described above cannot fully account for all uncertainties, and thus ultimately expert judgement is required to give a calibrated assessment of whether a specific cause is responsible for a given climate change.

The Fifth Assessment Report makes the following statement: (Cramer et al. 2014):

“Two broad challenges to the detection and attribution of climate change impacts relate to observations and process understanding. On the observational side, high-quality, long-term data relating to natural and human systems and the multiple factors affecting them are rare. In addition, the detection and attribution of climate change impacts requires an understanding of the processes by which climate change, in conjunction with other factors, may affect the system in question.”

Cramer, W., G.W. Yohe, M. Auffhammer, C. Huggel, U. Molau, M.A.F. da Silva Dias, A. Solow, D.A. Stone, and L. Tibig, 2014: Detection and attribution of observed impacts. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change pp. 979-1037

Because of the complexity of the causal chains in the climate system, investigation of these relationships is exceptionally challenging.

6.2 Attribution methods

The Intergovernmental Panel on Climate Change (IPCC) employs several attribution methods to assess the causes of observed climate changes, distinguishing between natural and human-induced factors. Below is a concise description of the key attribution methods used by the IPCC:

Optimal Fingerprinting uses statistical techniques to compare observed climate data with climate model simulations of the responses to individual forcings (e.g., anthropogenic greenhouse gases, aerosols, natural forcings like solar variability). A regression model estimates the contribution of each forcing to observed changes, accounting for natural variability and model uncertainties.

Pattern Correlation Methods analyze spatial or temporal patterns of climate variables (e.g. temperature or precipitation) to identify similarities between observed changes and model-simulated responses to specific forcings. This method is useful for attributing shifts in atmospheric circulation or sea surface temperature patterns.

Time Series Analysis examines temporal changes in climate variables to attribute trends to specific forcings. This approach compares long-term observed trends to model simulations with and without anthropogenic forcings. This method helps distinguish between short-term natural variability (e.g., El Nino) and long-term anthropogenic signals.

Multi-Step Attribution connects changes to impacts and then to forcings. An example is linking greenhouse gas emissions to warming, warming to increased heatwaves, and heatwaves to specific societal impacts.

Process-Based Attribution focuses on understanding the physical mechanisms behind observed changes. This approach combines observations, climate models, and theoretical understanding to attribute changes in specific processes to forcings. This approach is often used for regional climate phenomena, such as monsoon changes or polar amplification

Multi-Model and Ensemble Approaches use multiple climate models (e.g. CMIP6 ensemble) to account for uncertainties and improve confidence in attribution results. Large ensembles of simulations help separate the forced climate signal from internal variability.

Extreme Event Attribution assesses the role of human influence in the likelihood of occurrence or intensity of extreme weather events (e.g. heat waves, droughts). Methods include:

- Fraction of Attributable Risk quantifies how much anthropogenic climate change has altered the probability of an event
- Probabilistic Event Attribution uses large ensembles of climate model simulations to compare event likelihood in a world with and without human influence
- Storyline Approach examines the physical processes driving an event and evaluates how anthropogenic forcings modified those processes

6.3 Attribution of global warming

Attribution statements of global warming in the three most recent IPCC Assessment reports are:

AR4: “Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations.”

AR5: “It is *extremely likely* that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together. The best estimate of the human- induced contribution to warming is similar to the observed warming over this period.”

AR6: “The *likely* range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C. It is *likely* that well-mixed GHGs contributed a warming of 1.0°C to 2.0°C, other human drivers (principally aerosols) contributed a cooling of 0.0°C to 0.8°C, natural drivers changed global surface temperature by –0.1°C to +0.1°C, and internal variability changed it by –0.2°C to +0.2°C. It is *very likely* that well-mixed GHGs were the main driver of tropospheric warming since 1979.”

The AR4 and AR5 attribution statements reference the warming to the mid-20th century, the period when greenhouse gas emissions began rapidly increasing. The words “most” and “more than half” are deliberately imprecise, potentially ranging from 51 to 99% of the warming – presumably this imprecision is to account for potential structural uncertainties such as natural internal variability. The confidence level increases from *very likely* to *extremely likely* from AR4 to AR5. The structure of the attribution statement in the AR6 is fundamentally different, referencing the warming to the period 1850-1900. The AR6 attribution statement is more precise numerically, but with a lower level of confidence at “likely” – the AR6 attributes essentially all of the warming to increases in greenhouse gases. The most confident statement from the AR6 relates to the tropospheric warming since 1979, using the words “main driver” and “*very likely*.”

There are two areas of substantive criticism of the IPCC assessment of the causes of the recent warming: inadequate assessment of natural climate variability, and inappropriate statistical methods. Both of these issues are relevant not only in context of the main policy-relevant statement of the IPCC concerning attribution of the recent warming, but also because the global warming attribution provides the basis for extreme event attribution

6.3.1 Natural climate variability

The IPCC AR6 states that natural external drivers since 1850-1900 have changed global surface temperature by –0.1°C to +0.1°C, and internal variability has changed it by –0.2°C to +0.2°C – on average, having essentially no net impact on the warming since 1850-1900. This assessment of the contributions of natural variability has been disputed by a number of publications that question the magnitudes of the contributions from solar forcing and internal variability from the large-scale ocean circulations.

If the Equilibrium Climate Sensitivity to CO₂ is low (REF PREVIOUS CHAPTER), then natural climate variability becomes more important in the attribution of the recent warming. Further, if natural variability is higher, then estimates of the Equilibrium Climate Sensitivity from the historical period would be lower (Scafetta, 2023).

Connolly, R.; Soon, W.; Connolly, M.; Baliunas, S.; Berglund, J.; Butler, C.J.; Cionco, R.G.; Elias, A.G.; Fedorov, V.M.; Harde, H.; et al. How Much Has the Sun Influenced Northern Hemisphere Temperature Trends? An Ongoing Debate. *Res. Astron. Astrophys.* 2021, 21, 131.

Soon, W.; Connolly, R.; Connolly, M.; Akasofu, S.-I.; Baliunas, S.; Berglund, J.; Bianchini, A.; Briggs, W.M.; Butler, C.J.; Cionco, R.G.; et al. The Detection and Attribution of Northern Hemisphere Land Surface Warming (1850–2018) in Terms of Human and Natural Factors: Challenges of Inadequate Data. *Climate* 2023, 11, 179. <https://doi.org/10.3390/cli11090179>

Scafetta, N (2023) Empirical assessment of the role of the Sun in climate change using balanced multi-proxy records. *Geoscience Frontiers*,

Solar variability

The IPCC AR5 concluded that the best estimate of radiative forcing due to Total Solar Irradiance (TSI) changes for the period 1750–2011 was 0.05 W/m^2 . The IPCC AR6 acknowledges a much larger range of estimates of changes in TSI over the last several centuries, stating that the TSI between the Maunder Minimum (1645–1715) and the second half of the twentieth century increased by $0.7\text{--}2.7 \text{ W/m}^2$, a range that includes both low and high variability TSI data sets.⁴¹ However, the recommended forcing dataset for the CMIP6 climate model simulations used in the AR6 for attribution studies averages two data sets with low solar variability.⁴² (FOOTNOTE REFS FROM CH 8 of book)

While the IPCC AR6 shows a substantially greater solar impact than does the AR5, the overall impact on the climate was assessed to be small compared to anthropogenic forcing of climate change. However, the impact of solar variations on the climate is uncertain and subject to substantial debate CLIMATE DIALOG REF FROM BOOK - something that you would not infer from the IPCC assessment reports.

Exactly how TSI has changed over time has been a challenging problem to resolve. Since 1978, there have been direct measurements of TSI from satellites. However, the data exhibit non-negligible inconsistencies, and interpreting any multi-decadal trends in TSI requires comparisons of observations from overlapping satellites. Substantial uncertainty exists in the TSI composites, particularly owing to a gap in coverage during 1989 to 1992 that prevented direct cross-calibrations between two successive satellites. This rather arcane issue of cross-calibration of two satellite records has profound implications. There are a number of rival composite TSI datasets, disagreeing as to whether TSI increased or decreased during the period 1986–96. Further, the satellite record of TSI is used for calibrating proxy models, whereby past solar variations are inferred from sunspots and cosmogenic isotope measurements.³⁷

There is substantial evidence for high solar activity in the second half of the 20th century (starting in 1959) and extending into the 1990's, before a decline in the early 21st century; this period is often termed the “Modern Maximum.”

Chatzistergos et al. 2023, Solanki et al. 2004, Usoskin et al. 2007

However, some scientists have concluded that it is not possible to be confident of any multi-decadal trend in TSI (Schmutz, 2021).

As a result of this uncertainty, some reconstructions for past values of TSI (since 1750) have low variability, implying a very low impact of solar variations on global mean surface temperature, whereas datasets with high TSI variability can explain more than 70% percent of the temperature

variability since preindustrial times (Soon et al., 2023, Connolly et al, 2021). Hence, the choice of which TSI satellite record used in an analysis can substantially influence how much climate change is attributed to human versus natural forcings.

Chatzistergos, T., et al. (2023). Long-term changes in solar activity and irradiance. *Journal of Atmospheric and Solar-Terrestrial Physics*. [Link](#)

Connolly, R., et al. (2021). How much has the Sun influenced Northern Hemisphere temperature trends? An ongoing debate. *arXiv*. [Link](#)

Connolly et al., “Challenges in the Detection and Attribution of Northern Hemisphere Surface Temperature Trends Since 1850.”

A review article on this topic was recently published in the journal *Research in Astronomy and Astrophysics* (Connolly et al., 2023). The article had 23 co-authors with a range of perspectives, but who were united by their agreement not to take the consensus approach of the IPCC. Rather, the paper emphasized where dissenting scientific opinions exist as well as identifying areas where there is scientific agreement. The authors found that the Sun/climate debate is an issue where the IPCC’s consensus statements were prematurely achieved through the suppression of dissenting scientific opinions.

There is growing evidence that other aspects of solar variability, which are referred to as solar indirect effects, amplify TSI forcing or are independent of TSI forcing. Scafetta et al. (2023) suggests that ~80% of solar influence on climate may stem from non-TSI mechanisms. Candidate processes include: solar ultraviolet changes; energetic particle precipitation; atmospheric-electric-field effect on cloud cover; cloud changes produced by solar-modulated galactic cosmic rays; large relative changes in the magnetic field; and the strength of the solar wind. Solar indirect effects are not included in climate models, although indirect methods of estimating these effects suggest significant influence. However, claims of non-TSI mechanisms influencing climate are uncertain and debated.

□ Scafetta, N., et al. (2023). Empirical assessment of the role of the Sun in climate change using balanced multi-proxy solar records. *Geoscience Frontiers*. [Link](#)

Natural variability of large-scale ocean circulations

Variations in global mean surface temperature are linked to recurrent large-scale variations in ocean circulation patterns. These circulation patterns include the Atlantic Multidecadal Oscillation (AMO), the Pacific Decadal Oscillation (PDO) and the El Nino-Southern Oscillation (ENSO). These circulation patterns influence ocean heat uptake and heat distribution, and also influence atmospheric circulation patterns and cloud distributions. There is some debate as to whether these variations are strictly internal to the climate system, or whether this variability can have a solar/astronomical origin or can be influenced by large volcanic eruptions.

While climate models simulate the large-scale ocean circulations and internal climate variability, the simulated magnitude in the multi-decadal band is too low in most models relative to observations, and the phasing of the variability in long-term climate simulations is not synced with the actual, observed climate variations. Averaging multiple simulations from climate models effectively averages out the internal variations, leaving only the forced climate variability (e.g., CO₂ forcing). With most of the modern warming beginning in the late 1970’s, the recent 50-year warming is on the same time scale as

the multi-decadal oscillations of the AMO and PDO.

Here are summary statements from the IPCC AR5 and AR6 reports:

"Decadal variability in the Pacific, associated with the PDO or IPO, contributes significantly to regional and global temperature trends, but the relative contributions of internal variability and external forcing are difficult to disentangle in CMIP5 simulations." (AR5 Chapter 10, Section 10.3.1, p. 10- 28)

"Since AR5, there has been increased understanding of the role of internal variability, such as ENSO, PDO, and AMO, in modulating regional climate trends. However, limitations in simulating the exact timing and amplitude of these modes in CMIP6 models contribute to uncertainties in attributing observed changes to anthropogenic forcing (high confidence)." (AR6 Chapter 3, Section 3.7, p. 3-115)

The amplitude of the peak-to-trough impact of the multi-decadal oscillations on global temperatures has been assessed by the IPCC AR6: "The likely range of change due to internal variability is -0.2°C to $+0.2^{\circ}\text{C}$." This implies a trough-to-peak change of 0.4°C . Over many centuries, any global temperature changes from the troughs and peaks will cancel out, with little to no net impact.

However, with a nominal timescale of 60-80 years for oscillations such as the AMO and PDO, the timing of the peaks and troughs can be confused with the secular trend. This becomes very relevant for attributing the warming for the 50 years since 1975, during which most of the warming has occurred. Even if climate models have the correct amplitude of the multidecadal oscillations, the timing of the peaks and troughs is not adequately simulated, with each model and individual ensemble simulating a different phasing. Once the simulations of the ensemble members and different models are averaged, the natural internal variability contribution is averaged out, effectively cancelling the role of natural internal variability in the attribution process.

The Great Pacific Climate Shift of 1976-1977 was a notable climatic event characterized by an abrupt change in the North Pacific Ocean's atmosphere-ocean system that interacted with global climate patterns. This shift is closely associated with the Pacific Decadal Oscillation (PDO) that oscillates between warm and cool phases over decades. The 1976 shift marked a transition from a predominantly negative (cool) PDO phase (1947–1976) to a positive (warm) phase (1977 through 2000), with significant implications for global and regional climate patterns including the frequencies of El Nino and La Nina events. The Great Pacific Climate Shift coincided with the beginning of a period of accelerated global warming (REF TO A FIG OF GLOBAL TEMP ANOMALIES ELSEWHERE IN DOC) When the Great Pacific Climate Shift is accounted for in climate attribution analyses since 1950, it has been found that 40 percent or more of the warming in the second half of the 20th century was caused by natural internal variability (McLean et al, 2009; Tung and Zhou, 2013; Chylek et al., 2016; Scafetta, 2021).

McLean et al. (2009) "Influence of the Southern Oscillation on tropospheric temperature," J. Geophys. Res., 114

Ka-Kit Tung and Jiansong Zhou, "Using Data to Attribute Episodes of Warming and Cooling in Instrumental Records," Proceedings of the National Academy of Sciences 110, no. 6 (January 23, 2013): 2058–2063, <https://doi.org/10.1073/pnas.1212471110> .

Petr Chylek et al., “The Role of Atlantic Multi-Decadal Oscillation in the Global Mean Temperature Variability,” *Climate Dynamics* 47, no. 9–10 (February 20, 2016): pp. 3271–3279, <https://doi.org/10.1007/s00382-016-3025-7>.

Scafetta, N. Reconstruction of the Interannual to Millennial Scale Patterns of the Global Surface Temperature. *Atmosphere* 2021, 12, 147. <https://doi.org/10.3390/atmos12020147>

6.3.2 *Statistical methods*

Optimal fingerprinting is a statistical technique that compares observed climate data with climate model simulations to identify patterns (or "fingerprints") associated with human influence. Optimal fingerprinting has been heavily used in the climate literature for establishing attribution; studies applying it have been cited thousands of times, and it has been prominently featured by the IPCC since the Third Assessment Report in 2001.

A series of papers by McKittrick (McKittrick, 2022; McKittrick et al., 2023; McKittrick, 2024) has challenged the statistical methods commonly used in optimal fingerprinting and broader attribution analyses, based on commonly adopted practices in econometrics. These critiques highlight potential biases that could lead to over- or under-estimation of human influence on climate, and problems with the method that reduce confidence in the analysis results.

McKittrick (2022) challenged the methodology introduced by Allen and Tett (1999) for climate change attribution, which is a cornerstone of optimal fingerprinting. McKittrick argues that this methodology violates key conditions of the Gauss-Markov theorem, particularly the requirement that the conditional expectation of errors must be zero. This violation leads to biased and inconsistent estimates of attribution, undermining the reliability of the method.

McKittrick et al. (2023) addresses a paradox in climate attribution studies: standard trend models assume stationary (mean-reverting) error terms, while the climate econometrics literature suggests that if anthropogenic forcing is dominant, temperature trends should exhibit nonstationary (unit root) error terms, which could serve as a "fingerprint" for human influence. McKittrick and co-authors use tools from time series econometrics to resolve this issue, formalizing a hypothesis that temperature series contain both a nonstationary forcing component (due to anthropogenic influences) and a stationary "weather noise" component. This combination can bias unit root tests toward over-rejection, leading to misinterpretations in attribution studies.

McKittrick (2024) addresses the concern that for more than 20 years climate scientists—virtually alone among scientific disciplines—have used Total Least Squares (TLS) to estimate anthropogenic greenhouse gas signal coefficients, despite its tendency to be unreliable unless some strong assumptions hold that in practice are unlikely to be true. Under conditions which easily arise in optimal fingerprinting for climate attribution, TLS yields estimates with large positive biases. Thus, any study that has used TLS for optimal fingerprinting without verifying that it is appropriate in the specific data context has likely overstated the result.

While these analyses do not prove that all of the results from using these methods are wrong, it does show that the basis on which they were believed to be correct is non-existent – hence reducing confidence in the results. McKittrick's work underscores the importance of statistical rigor in attributing climate changes and the need to bridge the gap between econometric and climatological approaches.

6.4 Extreme event attribution

The IPCC AR6 provides an ambiguous assessment of the role of global warming in the historical record extreme weather and climate events. Chapter 11 of WG1 states:

"Evidence of observed changes in extremes and their attribution to human influence (including greenhouse gas and aerosol emissions and land-use changes) has strengthened since AR5, in particular for extreme precipitation, droughts, tropical cyclones and compound extremes (including dry/hot events and fire weather). Some recent hot extreme events would have been extremely unlikely to occur without human influence on the climate system."

By contrast, Chapter 12 of WG1 (Table 12.12) paints a different picture – presumably, the expert judgment of different groups of authors for the two chapters came to different conclusions:

- High confidence in an increase in extreme heat events in tropical regions where observations allow trend estimation and in most regions in the mid-latitudes, medium confidence elsewhere
- Medium confidence in a decrease in extreme cold events in Australia, Africa and most of northern South America where observations allow trend estimation
- No evidence of emergence in the historical period of a change in river floods, heavy precipitation, drought, fire weather, severe wind storms, and tropical cyclones

While the overall issue of detecting changes in extreme weather events and their attribution remains ambiguous, most of the activity in this area relates to the attribution of single extreme weather events. The most prominent effort is the World Weather Attribution (WWA) [WEB LINK](#), which is an international research initiative that focuses on extreme event attribution, analyzing how climate change influences the likelihood and intensity of extreme weather events. The approach used by the WWA runs large ensembles of regional climate models to compare the event in today's climate versus a pre-industrial climate without human-caused warming. WWA plays a significant role in linking extreme weather to climate change, using rapid probabilistic attribution to inform public and policy discussions.

However, the WWA's non-peer-reviewed reports, funding ties, and methodological challenges have sparked controversies, with critics questioning the robustness and impartiality of its conclusions. Despite these issues, WWA's work continues to shape climate science and media narratives. Technical criticisms of the approach include: neglect of a formal detection process; an implicit assumption that 100% of the post-industrial warming is caused by CO₂; and failure to adequately account for natural internal climate variability.

Beyond the issues raised by event attribution approaches, there exist major challenges to the detection step – a step that is commonly skipped, contra to the IPCC's established detection and attribution approach. Extreme events are by definition rare. Many analyses of extreme event types (including the US National Assessment Reports) only evaluate data since 1950 or 1970. However, as emphasized by Chapter xxx, many of the worst extreme weather and climate events in U.S. history occurred in the first half of the 20th century and the 19th century. And if paleoclimate reconstructions are also considered, it becomes very difficult for an event to pass the detection thresholds of exceeding what is expected from natural variability, particularly if a reasonably sized geographic region is considered.

In spite of these concerns, the U.S. is presently considering something like the WWA, which is being investigated by a NASEM Panel on Attribution of Extreme Weather and Climate Events and their impacts.

<https://www.nationalacademies.org/our-work/attribution-of-extreme-weather-and-climate-events-and-their-impacts>

Extreme weather events can be extreme in terms of the magnitude of individual events, the frequency of events crossing some threshold, or clustering of extreme events. It needs to be acknowledged that extreme events are by definition rare, and short historical records (even century long records) are insufficient for formulating meaningful statistics about return times and event likelihood.

Case studies from two recent high impact extreme events in the U.S. are provided to illustrate the challenges and ambiguities in attributing the frequency and intensity of extreme weather events to human-caused warming.

6.4.1 Case study – 2021 Western North America heat wave

The 2021 Western North America heat wave was an extreme heat wave that affected much of Western North America in late June 2021. In particular, surface temperature records were set in Portland, OR (115 °F; previous record 107°F) and Seattle, WA (108 °F; previous record 103°F).

The WWA provided the following attribution statements:

<https://www.worldweatherattribution.org/western-north-american-extreme-heat-virtually-impossible-without-human-caused-climate-change/>

<https://www.worldweatherattribution.org/wp-content/uploads/NW-US-extreme-heat-2021-scientific-report-WWA.pdf>

- Based on observations and modeling, the occurrence of this heatwave was virtually impossible without human-caused climate change.
- The event is estimated to be about a 1 in 1000-year event in today's climate.
- The event would have been at least 150 times rarer without human-induced climate change.
- This heatwave was about 2°C hotter than it would have been if it had occurred at the beginning of the industrial revolution (when global mean temperatures were 1.2°C cooler than today).

Mass et al. (2024) summarizes the proximate sequence of compound events leading to the heat wave. There was a record-breaking midtropospheric ridge over the Pacific Northwest, forced by a tropical disturbance in the western Pacific. This produced record-breaking midtropospheric temperatures, strong subsidence in the lower atmosphere, low-level easterly flow that produced downslope warming on regional terrain and the removal of cooler marine air, and an approaching low-level trough that enhanced downslope flow. The event occurred at a time of maximum solar insolation, and drier-than-normal soil moisture. Using a storyline approach, Mass et al. assessed that there is no trend in drought and dry soils in the Pacific Northwest; there is no evidence of global warming producing stronger ridges of high pressure, and no observed trend in heat waves or record temperatures in the region. They concluded that although anthropogenic warming may have contributed as much as 2°F to the magnitude of the event, there is little evidence of further amplification of the event from increasing greenhouse gases.

<https://journals.ametsoc.org/view/journals/wefo/39/2/WAF-D-23-0154.1.xml>

A more sophisticated statistical analysis of a model-based attribution study of this heat wave was conducted by Bercos-Hickey et al. (2022)

<https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2022GL099396> Because this event is a far outlier and far above the bounds of Generalized Extreme Value distributions fitted from historical data, they concluded that estimates of return times, quantitative changes in event magnitude and frequency, and probability of the extreme temperatures such as provided by the WWA are not accurate and are made with low confidence. They found that hindcast attribution methods using an ensemble of regional climate models, combined with Pearl (2009) causal inferences, can provide limited and conditional information about the magnitude of the human influence on this heatwave – they provided a more highly constrained estimate that human activities caused a ~1.4°C–1.8°F increase in the daily maximum temperatures.

The 2021 Western North America heatwave was a rare and unprecedented compound weather event, that broke century-old temperature records by as much as 9°F. While there is little doubt that anthropogenic global warming contributed to the probability and magnitude of the extreme temperatures, the uniqueness of the event challenges quantifying this influence by traditional event attribution methods.

Van Oldenborgh et al. (2022) summarize the challenges of attributing heat waves.

<https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2021EF002271>

A warming climate means that a fixed temperature threshold is passed more often, and hence the probability of extreme heat increases. However, land use changes, vegetation change, irrigation, air pollution, and other changes also drive local and regional trends in heatwaves. Sometimes these factors enhance heatwave intensity, but they can also counteract the effects of climate change. Temperature variability is unrealistic in many climate models, and can fail standard quality checks. Therefore, reliable attribution of heatwaves remains a major scientific challenge in many regions, particularly where the moisture budget is not well simulated, and where land surface changes, changes in short-lived forcings, and soil moisture interactions are important.

6.4.2 Case study – Hurricane Harvey rainfall ~~IDONT LOVE THIS EXAMPLE. DELETE? MAYBE SOMETHING ELSE?~~

Hurricane Harvey made landfall in southern Texas on August 24, 2017 as a Category 4 hurricane. The primary damage from Harvey occurred after the storm had been downgraded to a tropical storm and stalled near the coastline with a stationary front along the TX/LA border, dropping torrential and unprecedented amounts of rainfall over Texas. Hurricane Harvey provides an informative example of the challenges of detection for a rare event, and also the complexity of extraneous factors that can influence such an event.

The first issue to consider is detection. Harvey set the record for most amount of rainfall from a continental U.S. landfalling hurricane (60 inches), going back at least to the 1880's when comprehensive records begin (Landsea, 2017). The previous top four rainfall producers for U.S. landfalling hurricanes were: Tropical Storm Amelia (1978) with 48 inches in Texas, Hurricane Easy (1950) with 45 inches in Florida, Tropical Storm Claudette (1979) with 45 inches in Florida, and Tropical Storm Allison (2001) with 40 inches in Texas. Looking more broadly at North American hurricanes that made landfall in Central American and the Caribbean, Roth (2017) identifies the following landfalling hurricanes that produced more rainfall than Harvey: 100 inches in Cuba from Hurricane Flora (1963), 96 inches in Jamaica from the November 1909 Hurricane, 63 inches in Nicaragua from Hurricane Mitch (1998), and 62 inches in Mexico from Hurricane Wilma (2005). Hurricane Harvey's rainfall arguably meets the detection criteria, whereby an attribution analysis is justified, although Harvey's rainfall was far from unprecedented from historic Atlantic hurricane landfalls.

In addressing the attribution of extreme rainfall from a landfalling hurricanes, there are several factors leading to excessive rainfall that aren't associated with temperature. Slow motion of the hurricane near landfall can lead to high amounts of local rainfall (e.g. Wilma – 2005; Harvey – 2017;). Mountains/hills near the coast magnify rainfall potential due to forced upslope flow (e.g. Mitch – 1998). Upper-level troughs and cold fronts can lead to excessive rainfall (e.g. Floyd – 1999). Horizontally large tropical cyclones have larger rain footprints, which can lead to excessive rainfall owing to the longer time frame over which rainfall falls at any one location.

The WWA attribution analysis of Hurricane Harvey's rainfall (Oldenburgh et al., 2017) found that human-caused climate change made the heavy rainfall associated with Hurricane Harvey roughly three times more likely and 15% more intense.

<https://iopscience.iop.org/article/10.1088/1748-9326/aa9ef2#:~:text=This%20would%20indicate%20that%20the,to%20Houston's%20flood%20protectio n%20system.&text=Author%20to%20whom%20any%20correspondence%20should%20be%20addressed>

Several publications based on model simulations have concluded that as much as 40% of the rainfall from Hurricane Harvey was caused by human-caused global warming (Emanuel 2017; Risser and Wehner 2017). The rationale for these assessments was that prior to the beginning of summer of 2017, sea surface temperatures in the western Gulf of Mexico exceeded 86 °F and ocean heat content was the highest on record in the Gulf of Mexico (Trenberth et al. 2017). However, El Niño–Southern Oscillation (ENSO) and Atlantic circulation patterns contributed to this elevated heat content.

Landsea (2017) summarizes the arguments for more rainfall from tropical cyclones traveling over a warmer ocean. Simple thermodynamic calculations suggest that the amount of rainfall in the tropical latitudes would increase by about 4% per °F of sea surface temperature increase. Examining a 300 mile radius circle for nearly all of the rain implies that about 10% more total hurricane rainfall for a warming of 2-2.5 °F. The Gulf of Mexico has warmed about 0.7 °F since 1960. Even if it is assumed that all of this warming is due to manmade global warming suggests that roughly 3% of hurricane rainfall today can be reasonably attributed to manmade global warming. Hence, only about 2 inches of Hurricane Harvey's peak amount of 60 inches can be linked to manmade global warming.

Aryal et al. (2018) examined the contribution of North Atlantic hurricanes to flooding and heavy rainfall across the continental U.S. Their analysis does not point to any significant changes in the magnitude or frequency of floods. They found that the North Atlantic Oscillation (NAO) plays a significant role in hurricane-related extreme rainfall along the U.S. East Coast, while ENSO is most strongly linked to the hurricane-related precipitation in Texas.

With regards to the rainfall associated with landfalling hurricanes, there is no clear signal of increasing rainfall owing to the complexity of the factors contributing to hurricane-induced rainfall.

6.5 Summary

There is an ongoing scientific debate around attribution methods, particularly in attributing extreme weather events to climate change. The IPCC has long cautioned that methods to establish causality in climate science are inherently uncertain and ultimately depend on expert judgement.

There are two areas of substantive criticism of the IPCC assessment of the causes of the recent warming: inadequate assessment of natural climate variability, and inappropriate statistical methods.

Detection of extreme weather events is challenged by their rarity, requiring a long data set and a choice of region and spatial scale to evaluate their occurrence against the background of natural weather and climate variability.

The most robust attribution statements for an extreme event relate to an incremental change (e.g. a temperature change or percent change in rainfall). Statements related to return times, quantitative changes in event magnitude and frequency, and probability of the extremes are not accurate and are made with low confidence. There is no evidence in a change of weather or climate regime patterns from increasing greenhouse gases that would amplify or dampen extreme weather events.

From: Judith Curry <curry.judith@gmail.com>
Sent: Friday, May 2, 2025 3:26 PM
To: Ross McKittrick
Cc: Roy Spencer; Steven Koonin; Travis Fisher; John Christy
Subject: Re: my suggested edits of 4
Attachments: 6 combined.docx

oops previous was sent prematurely

Ross, in my attribution chapter (attached), the statistical issues you raise are about 20% of the overall issue.

Outline is

Introduction

Attribution methods (others besides optimal fingerprinting

Attribution of global warming

Solar variability

Natural internal variability of large-scale ocean circulations

Uncertainties in statistical methods

Extreme event attribution

Case study - 2021 Western North American heat wave

Case study - Hurricane Harvey rainfall

Summary

Radiative forcing and attribution are two fundamentally different topics

On Fri, May 2, 2025 at 12:18 PM Judith Curry <curry.judith@gmail.com> wrote:

Ross, in my attribution chapter (attached), the statistical issues you raise are about 20% of the overall issue.

Outline is

Introduction

Attribution methods (others besides optimal fingerprinting

Attribution of global warming

On Fri, May 2, 2025 at 12:12 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

There are going to be a few places where topics arguably belong in two or more places, and we may find it hard to settle that until we have something like a complete draft to read through at one sitting. I like having the solar and aerosol discussion here as part of the topic of influences (including natural ones) on the climate. I think the important thing about the attribution chapter is explaining that scientists use statistical methods to infer causation in the absence of experimental evidence and there are problems/limitations with any such methods.

I have no trouble reducing the use of quotes. I tend to over-include them because I think people need to see that the cited sources actually said what is attributed, but lengthy inset quotes slow down the flow. And I'm fine switching the Zacharias quote out (there are even shabbier ones from Lean) and replacing it with the Connolly summary.

To Roy's point: I think we make a start at articulating the importance of natural influences in Part I, but if more needs to be said Roy maybe you could try drafting some text.

Ross

On Fri, May 2, 2025 at 2:53 PM Roy Spencer <roywspencer@hotmail.com> wrote:

I feel like there is a disconnect that results from the first 2 Parts, and I am willing to be overruled by the majority on this:

Part I: Direct human influence on ecosystems and the climate

Part II: Climate response to greenhouse gas emissions

Part II addresses "attribution", but the reader might well ask, if there are only **human** influences on climate worthy of description in Part I, then why discuss uncertainties over attribution, if you've only told me about humans influencing the climate?

This is why I previously pointed out that radiative forcing of the climate system can be NATURAL as well as anthropogenic. We have papers published, as does Dick Lindzen, and maybe Judith Curry as well, discussing this.

All you have to do is look at the large variability in TOA radiative flux anomalies vs. surface temperature anomalies, and you can see that most of those flux variations are NOT feedback-related (linearly related to temperature), they instead PRECEDE temperature changes and so are the CAUSE of temperature changes (natural radiative forcing). This is natural radiative forcing (because in the forcing-feedback paradigm of climate change, if it's not feedback, it's forcing).

Unless we are willing to challenge the premise that external (TOA) radiative forcing is ONLY due to humans and volcanoes, we lose the chance to point out, up front, that the climate system can cause its own radiative forcing, and thus climate change.

Do we KNOW this has happened on climate time scales? No. But there is an awful lot of evidence of the RWP, MWP, and LIA. What caused them? We really don't know.

But simply assuming (for example) that the average albedo of Earth has been divinely inspired to be a constant 0.300 for ever and ever amen seems rather presumptuous.

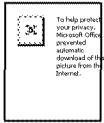
Just my 2 cents.

-Roy

From: Steven Koonin
Sent: Friday, May 2, 2025 12:53 PM
To: 'Judith Curry'; 'Roy Spencer'
Cc: 'Ross McKittrick'; 'Travis Fisher'; 'John Christy'
Subject: my suggested edits of 4

See attached. Now on to 5!

SEK



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

6.1 Introduction

Detection and attribution is concerned with assessing the causal relationship between one or more drivers and a responding system. The Intergovernmental Panel on Climate Change (IPCC) provides clear definitions for detection and attribution in climate science, based on their Sixth Assessment Report (AR6). These terms are crucial for understanding climate change impacts and are used to assess whether observed changes are significant and what caused them. As defined by the IPCC AR6 WGI Glossary:

Detection: "Detection of change is defined as the process of demonstrating that climate or a system affected by climate has changed in some defined statistical sense, without providing a reason for that change. An identified change is detected in observations if its likelihood of occurrence by chance due to internal variability alone is determined to be small, for example, <10%."

Attribution: "Attribution is defined as the process of evaluating the relative contributions of multiple causal factors to a change or event with a formal assessment of confidence."

The definition of detection emphasizes a statistical approach, focusing on whether changes are significant enough to stand out from natural variability without yet attributing causes.

The attribution process involves assessing how much human activities, such as industrial emissions, versus natural factors, like volcanic eruptions, contribute to observed changes, with a structured confidence level to reflect scientific certainty. Attribution requires the evaluation of the contributions of all external drivers to the system change.

While the IPCC's definitions are clear, there is ongoing scientific debate around attribution methods, particularly in attributing extreme weather events to climate change. The IPCC has long cautioned that methods to establish causality in climate science are inherently uncertain and ultimately depend on expert judgement. The Fourth Assessment Report (Hegerl et al. 2007 p. 668) explained it as follows:

‘Attribution’ of causes of climate change is the process of establishing the most likely causes for the detected change with some defined level of confidence... unequivocal attribution would require controlled experimentation with the climate system. Since that is not possible, in practice attribution of anthropogenic climate change is understood to mean demonstration that a detected change is ‘consistent with the estimated responses to the given combination of anthropogenic and natural forcing’ and ‘not consistent with alternative, physically plausible explanations of recent climate change that exclude important elements of the given combination of forcings’ (IPCC, 2001)... The approaches used in detection and attribution research described above cannot fully account for all uncertainties, and thus ultimately expert judgement is required to give a calibrated assessment of whether a specific cause is responsible for a given climate change.

The Fifth Assessment Report makes the following statement: (Cramer et al. 2014):

“Two broad challenges to the detection and attribution of climate change impacts relate to observations and process understanding. On the observational side, high-quality, long-term data relating to natural and human systems and the multiple factors affecting them are rare. In addition, the detection and attribution of climate change impacts requires an understanding of the processes by which climate change, in conjunction with other factors, may affect the system in question.”

Cramer, W., G.W. Yohe, M. Auffhammer, C. Huggel, U. Molau, M.A.F. da Silva Dias, A. Solow, D.A. Stone, and L. Tibig, 2014: Detection and attribution of observed impacts. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change pp. 979-1037

Because of the complexity of the causal chains in the climate system, investigation of these relationships is exceptionally challenging.

6.2 Attribution methods

The Intergovernmental Panel on Climate Change (IPCC) employs several attribution methods to assess the causes of observed climate changes, distinguishing between natural and human-induced factors. Below is a concise description of the key attribution methods used by the IPCC:

Optimal Fingerprinting uses statistical techniques to compare observed climate data with climate model simulations of the responses to individual forcings (e.g., anthropogenic greenhouse gases, aerosols, natural forcings like solar variability). A regression model estimates the contribution of each forcing to observed changes, accounting for natural variability and model uncertainties.

Pattern Correlation Methods analyze spatial or temporal patterns of climate variables (e.g. temperature or precipitation) to identify similarities between observed changes and model-simulated responses to specific forcings. This method is useful for attributing shifts in atmospheric circulation or sea surface temperature patterns.

Time Series Analysis examines temporal changes in climate variables to attribute trends to specific forcings. This approach compares long-term observed trends to model simulations with and without anthropogenic forcings. This method helps distinguish between short-term natural variability (e.g., El Nino) and long-term anthropogenic signals.

Multi-Step Attribution connects changes to impacts and then to forcings. An example is linking greenhouse gas emissions to warming, warming to increased heatwaves, and heatwaves to specific societal impacts.

Process-Based Attribution focuses on understanding the physical mechanisms behind observed changes. This approach combines observations, climate models, and theoretical understanding to attribute changes in specific processes to forcings. This approach is often used for regional climate phenomena, such as monsoon changes or polar amplification

Multi-Model and Ensemble Approaches use multiple climate models (e.g. CMIP6 ensemble) to account for uncertainties and improve confidence in attribution results. Large ensembles of simulations help separate the forced climate signal from internal variability.

Extreme Event Attribution assesses the role of human influence in the likelihood of occurrence or intensity of extreme weather events (e.g. heat waves, droughts). Methods include:

- Fraction of Attributable Risk quantifies how much anthropogenic climate change has altered the probability of an event
- Probabilistic Event Attribution uses large ensembles of climate model simulations to compare event likelihood in a world with and without human influence
- Storyline Approach examines the physical processes driving an event and evaluates how anthropogenic forcings modified those processes

6.3 Attribution of global warming

Attribution statements of global warming in the three most recent IPCC Assessment reports are:

AR4: “Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations.”

AR5: “It is *extremely likely* that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together. The best estimate of the human- induced contribution to warming is similar to the observed warming over this period.”

AR6: “The *likely* range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C. It is *likely* that well-mixed GHGs contributed a warming of 1.0°C to 2.0°C, other human drivers (principally aerosols) contributed a cooling of 0.0°C to 0.8°C, natural drivers changed global surface temperature by –0.1°C to +0.1°C, and internal variability changed it by –0.2°C to +0.2°C. It is *very likely* that well-mixed GHGs were the main driver of tropospheric warming since 1979.”

The AR4 and AR5 attribution statements reference the warming to the mid-20th century, the period when greenhouse gas emissions began rapidly increasing. The words “most” and “more than half” are deliberately imprecise, potentially ranging from 51 to 99% of the warming – presumably this imprecision is to account for potential structural uncertainties such as natural internal variability. The confidence level increases from *very likely* to *extremely likely* from AR4 to AR5. The structure of the attribution statement in the AR6 is fundamentally different, referencing the warming to the period 1850-1900. The AR6 attribution statement is more precise numerically, but with a lower level of confidence at “likely” – the AR6 attributes essentially all of the warming to increases in greenhouse gases. The most confident statement from the AR6 relates to the tropospheric warming since 1979, using the words “main driver” and “*very likely*.”

There are two areas of substantive criticism of the IPCC assessment of the causes of the recent warming: inadequate assessment of natural climate variability, and inappropriate statistical methods. Both of these issues are relevant not only in context of the main policy-relevant statement of the IPCC concerning attribution of the recent warming, but also because the global warming attribution provides the basis for extreme event attribution

6.3.1 Natural climate variability

The IPCC AR6 states that natural external drivers since 1850-1900 have changed global surface temperature by –0.1°C to +0.1°C, and internal variability has changed it by –0.2°C to +0.2°C – on average, having essentially no net impact on the warming since 1850-1900. This assessment of the contributions of natural variability has been disputed by a number of publications that question the magnitudes of the contributions from solar forcing and internal variability from the large-scale ocean circulations.

If the Equilibrium Climate Sensitivity to CO₂ is low (REF PREVIOUS CHAPTER), then natural climate variability becomes more important in the attribution of the recent warming. Further, if natural variability is higher, then estimates of the Equilibrium Climate Sensitivity from the historical period would be lower (Scafetta, 2023).

Connolly, R.; Soon, W.; Connolly, M.; Baliunas, S.; Berglund, J.; Butler, C.J.; Cionco, R.G.; Elias, A.G.; Fedorov, V.M.; Harde, H.; et al. How Much Has the Sun Influenced Northern Hemisphere Temperature Trends? An Ongoing Debate. *Res. Astron. Astrophys.* 2021, 21, 131.

Soon, W.; Connolly, R.; Connolly, M.; Akasofu, S.-I.; Baliunas, S.; Berglund, J.; Bianchini, A.; Briggs, W.M.; Butler, C.J.; Cionco, R.G.; et al. The Detection and Attribution of Northern Hemisphere Land Surface Warming (1850–2018) in Terms of Human and Natural Factors: Challenges of Inadequate Data. *Climate* 2023, 11, 179. <https://doi.org/10.3390/cli11090179>

Scafetta, N (2023) Empirical assessment of the role of the Sun in climate change using balanced multi-proxy records. *Geoscience Frontiers*,

Solar variability

The IPCC AR5 concluded that the best estimate of radiative forcing due to Total Solar Irradiance (TSI) changes for the period 1750–2011 was 0.05 W/m^2 . The IPCC AR6 acknowledges a much larger range of estimates of changes in TSI over the last several centuries, stating that the TSI between the Maunder Minimum (1645–1715) and the second half of the twentieth century increased by $0.7\text{--}2.7 \text{ W/m}^2$, a range that includes both low and high variability TSI data sets.⁴¹ However, the recommended forcing dataset for the CMIP6 climate model simulations used in the AR6 for attribution studies averages two data sets with low solar variability.⁴² (FOOTNOTE REFS FROM CH 8 of book)

While the IPCC AR6 shows a substantially greater solar impact than does the AR5, the overall impact on the climate was assessed to be small compared to anthropogenic forcing of climate change. However, the impact of solar variations on the climate is uncertain and subject to substantial debate CLIMATE DIALOG REF FROM BOOK - something that you would not infer from the IPCC assessment reports.

Exactly how TSI has changed over time has been a challenging problem to resolve. Since 1978, there have been direct measurements of TSI from satellites. However, the data exhibit non-negligible inconsistencies, and interpreting any multi-decadal trends in TSI requires comparisons of observations from overlapping satellites. Substantial uncertainty exists in the TSI composites, particularly owing to a gap in coverage during 1989 to 1992 that prevented direct cross-calibrations between two successive satellites. This rather arcane issue of cross-calibration of two satellite records has profound implications. There are a number of rival composite TSI datasets, disagreeing as to whether TSI increased or decreased during the period 1986–96. Further, the satellite record of TSI is used for calibrating proxy models, whereby past solar variations are inferred from sunspots and cosmogenic isotope measurements.³⁷

There is substantial evidence for high solar activity in the second half of the 20th century (starting in 1959) and extending into the 1990's, before a decline in the early 21st century; this period is often termed the “Modern Maximum.”

Chatzistergos et al. 2023, Solanki et al. 2004, Usoskin et al. 2007

However, some scientists have concluded that it is not possible to be confident of any multi-decadal trend in TSI (Schmutz, 2021).

As a result of this uncertainty, some reconstructions for past values of TSI (since 1750) have low variability, implying a very low impact of solar variations on global mean surface temperature, whereas datasets with high TSI variability can explain more than 70% percent of the temperature

variability since preindustrial times (Soon et al., 2023, Connolly et al, 2021). Hence, the choice of which TSI satellite record used in an analysis can substantially influence how much climate change is attributed to human versus natural forcings.

Chatzistergos, T., et al. (2023). Long-term changes in solar activity and irradiance. *Journal of Atmospheric and Solar-Terrestrial Physics*. [Link](#)

Connolly, R., et al. (2021). How much has the Sun influenced Northern Hemisphere temperature trends? An ongoing debate. *arXiv*. [Link](#)

Connolly et al., “Challenges in the Detection and Attribution of Northern Hemisphere Surface Temperature Trends Since 1850.”

A review article on this topic was recently published in the journal *Research in Astronomy and Astrophysics* (Connolly et al., 2023). The article had 23 co-authors with a range of perspectives, but who were united by their agreement not to take the consensus approach of the IPCC. Rather, the paper emphasized where dissenting scientific opinions exist as well as identifying areas where there is scientific agreement. The authors found that the Sun/climate debate is an issue where the IPCC’s consensus statements were prematurely achieved through the suppression of dissenting scientific opinions.

There is growing evidence that other aspects of solar variability, which are referred to as solar indirect effects, amplify TSI forcing or are independent of TSI forcing. Scafetta et al. (2023) suggests that ~80% of solar influence on climate may stem from non-TSI mechanisms. Candidate processes include: solar ultraviolet changes; energetic particle precipitation; atmospheric-electric-field effect on cloud cover; cloud changes produced by solar-modulated galactic cosmic rays; large relative changes in the magnetic field; and the strength of the solar wind. Solar indirect effects are not included in climate models, although indirect methods of estimating these effects suggest significant influence. However, claims of non-TSI mechanisms influencing climate are uncertain and debated.

□ Scafetta, N., et al. (2023). Empirical assessment of the role of the Sun in climate change using balanced multi-proxy solar records. *Geoscience Frontiers*. [Link](#)

Natural variability of large-scale ocean circulations

Variations in global mean surface temperature are linked to recurrent large-scale variations in ocean circulation patterns. These circulation patterns include the Atlantic Multidecadal Oscillation (AMO), the Pacific Decadal Oscillation (PDO) and the El Nino-Southern Oscillation (ENSO). These circulation patterns influence ocean heat uptake and heat distribution, and also influence atmospheric circulation patterns and cloud distributions. There is some debate as to whether these variations are strictly internal to the climate system, or whether this variability can have a solar/astronomical origin or can be influenced by large volcanic eruptions.

While climate models simulate the large-scale ocean circulations and internal climate variability, the simulated magnitude in the multi-decadal band is too low in most models relative to observations, and the phasing of the variability in long-term climate simulations is not synced with the actual, observed climate variations. Averaging multiple simulations from climate models effectively averages out the internal variations, leaving only the forced climate variability (e.g., CO₂ forcing). With most of the modern warming beginning in the late 1970’s, the recent 50-year warming is on the same time scale as

the multi-decadal oscillations of the AMO and PDO.

Here are summary statements from the IPCC AR5 and AR6 reports:

"Decadal variability in the Pacific, associated with the PDO or IPO, contributes significantly to regional and global temperature trends, but the relative contributions of internal variability and external forcing are difficult to disentangle in CMIP5 simulations." (AR5 Chapter 10, Section 10.3.1, p. 10- 28)

"Since AR5, there has been increased understanding of the role of internal variability, such as ENSO, PDO, and AMO, in modulating regional climate trends. However, limitations in simulating the exact timing and amplitude of these modes in CMIP6 models contribute to uncertainties in attributing observed changes to anthropogenic forcing (high confidence)." (AR6 Chapter 3, Section 3.7, p. 3-115)

The amplitude of the peak-to-trough impact of the multi-decadal oscillations on global temperatures has been assessed by the IPCC AR6: "The likely range of change due to internal variability is -0.2°C to $+0.2^{\circ}\text{C}$." This implies a trough-to-peak change of 0.4°C . Over many centuries, any global temperature changes from the troughs and peaks will cancel out, with little to no net impact.

However, with a nominal timescale of 60-80 years for oscillations such as the AMO and PDO, the timing of the peaks and troughs can be confused with the secular trend. This becomes very relevant for attributing the warming for the 50 years since 1975, during which most of the warming has occurred. Even if climate models have the correct amplitude of the multidecadal oscillations, the timing of the peaks and troughs is not adequately simulated, with each model and individual ensemble simulating a different phasing. Once the simulations of the ensemble members and different models are averaged, the natural internal variability contribution is averaged out, effectively cancelling the role of natural internal variability in the attribution process.

The Great Pacific Climate Shift of 1976-1977 was a notable climatic event characterized by an abrupt change in the North Pacific Ocean's atmosphere-ocean system that interacted with global climate patterns. This shift is closely associated with the Pacific Decadal Oscillation (PDO) that oscillates between warm and cool phases over decades. The 1976 shift marked a transition from a predominantly negative (cool) PDO phase (1947–1976) to a positive (warm) phase (1977 through 2000), with significant implications for global and regional climate patterns including the frequencies of El Nino and La Nina events. The Great Pacific Climate Shift coincided with the beginning of a period of accelerated global warming (REF TO A FIG OF GLOBAL TEMP ANOMALIES ELSEWHERE IN DOC) When the Great Pacific Climate Shift is accounted for in climate attribution analyses since 1950, it has been found that 40 percent or more of the warming in the second half of the 20th century was caused by natural internal variability (McLean et al, 2009; Tung and Zhou, 2013; Chylek et al., 2016; Scafetta, 2021).

McLean et al. (2009) "Influence of the Southern Oscillation on tropospheric temperature," J. Geophys. Res., 114

Ka-Kit Tung and Jiansong Zhou, "Using Data to Attribute Episodes of Warming and Cooling in Instrumental Records," Proceedings of the National Academy of Sciences 110, no. 6 (January 23, 2013): 2058–2063, <https://doi.org/10.1073/pnas.1212471110> .

Petr Chylek et al., “The Role of Atlantic Multi-Decadal Oscillation in the Global Mean Temperature Variability,” *Climate Dynamics* 47, no. 9–10 (February 20, 2016): pp. 3271–3279, <https://doi.org/10.1007/s00382-016-3025-7>.

Scafetta, N. Reconstruction of the Interannual to Millennial Scale Patterns of the Global Surface Temperature. *Atmosphere* 2021, 12, 147. <https://doi.org/10.3390/atmos12020147>

6.3.2 Statistical methods

Optimal fingerprinting is a statistical technique that compares observed climate data with climate model simulations to identify patterns (or "fingerprints") associated with human influence. Optimal fingerprinting has been heavily used in the climate literature for establishing attribution; studies applying it have been cited thousands of times, and it has been prominently featured by the IPCC since the Third Assessment Report in 2001.

A series of papers by McKittrick (McKittrick, 2022; McKittrick et al., 2023; McKittrick, 2024) has challenged the statistical methods commonly used in optimal fingerprinting and broader attribution analyses, based on commonly adopted practices in econometrics. These critiques highlight potential biases that could lead to over- or under-estimation of human influence on climate, and problems with the method that reduce confidence in the analysis results.

McKittrick (2022) challenged the methodology introduced by Allen and Tett (1999) for climate change attribution, which is a cornerstone of optimal fingerprinting. McKittrick argues that this methodology violates key conditions of the Gauss-Markov theorem, particularly the requirement that the conditional expectation of errors must be zero. This violation leads to biased and inconsistent estimates of attribution, undermining the reliability of the method.

McKittrick et al. (2023) addresses a paradox in climate attribution studies: standard trend models assume stationary (mean-reverting) error terms, while the climate econometrics literature suggests that if anthropogenic forcing is dominant, temperature trends should exhibit nonstationary (unit root) error terms, which could serve as a "fingerprint" for human influence. McKittrick and co-authors use tools from time series econometrics to resolve this issue, formalizing a hypothesis that temperature series contain both a nonstationary forcing component (due to anthropogenic influences) and a stationary "weather noise" component. This combination can bias unit root tests toward over-rejection, leading to misinterpretations in attribution studies.

McKittrick (2024) addresses the concern that for more than 20 years climate scientists—virtually alone among scientific disciplines—have used Total Least Squares (TLS) to estimate anthropogenic greenhouse gas signal coefficients, despite its tendency to be unreliable unless some strong assumptions hold that in practice are unlikely to be true. Under conditions which easily arise in optimal fingerprinting for climate attribution, TLS yields estimates with large positive biases. Thus, any study that has used TLS for optimal fingerprinting without verifying that it is appropriate in the specific data context has likely overstated the result.

While these analyses do not prove that all of the results from using these methods are wrong, it does show that the basis on which they were believed to be correct is non-existent – hence reducing confidence in the results. McKittrick's work underscores the importance of statistical rigor in attributing climate changes and the need to bridge the gap between econometric and climatological approaches.

6.4 Extreme event attribution

The IPCC AR6 provides an ambiguous assessment of the role of global warming in the historical record extreme weather and climate events. Chapter 11 of WG1 states:

"Evidence of observed changes in extremes and their attribution to human influence (including greenhouse gas and aerosol emissions and land-use changes) has strengthened since AR5, in particular for extreme precipitation, droughts, tropical cyclones and compound extremes (including dry/hot events and fire weather). Some recent hot extreme events would have been extremely unlikely to occur without human influence on the climate system."

By contrast, Chapter 12 of WG1 (Table 12.12) paints a different picture – presumably, the expert judgment of different groups of authors for the two chapters came to different conclusions:

- High confidence in an increase in extreme heat events in tropical regions where observations allow trend estimation and in most regions in the mid-latitudes, medium confidence elsewhere
- Medium confidence in a decrease in extreme cold events in Australia, Africa and most of northern South America where observations allow trend estimation
- No evidence of emergence in the historical period of a change in river floods, heavy precipitation, drought, fire weather, severe wind storms, and tropical cyclones

While the overall issue of detecting changes in extreme weather events and their attribution remains ambiguous, most of the activity in this area relates to the attribution of single extreme weather events. The most prominent effort is the World Weather Attribution (WWA) [WEB LINK](#), which is an international research initiative that focuses on extreme event attribution, analyzing how climate change influences the likelihood and intensity of extreme weather events. The approach used by the WWA runs large ensembles of regional climate models to compare the event in today's climate versus a pre-industrial climate without human-caused warming. WWA plays a significant role in linking extreme weather to climate change, using rapid probabilistic attribution to inform public and policy discussions.

However, the WWA's non-peer-reviewed reports, funding ties, and methodological challenges have sparked controversies, with critics questioning the robustness and impartiality of its conclusions. Despite these issues, WWA's work continues to shape climate science and media narratives. Technical criticisms of the approach include: neglect of a formal detection process; an implicit assumption that 100% of the post-industrial warming is caused by CO₂; and failure to adequately account for natural internal climate variability.

Beyond the issues raised by event attribution approaches, there exist major challenges to the detection step – a step that is commonly skipped, contra to the IPCC's established detection and attribution approach. Extreme events are by definition rare. Many analyses of extreme event types (including the US National Assessment Reports) only evaluate data since 1950 or 1970. However, as emphasized by Chapter xxx, many of the worst extreme weather and climate events in U.S. history occurred in the first half of the 20th century and the 19th century. And if paleoclimate reconstructions are also considered, it becomes very difficult for an event to pass the detection thresholds of exceeding what is expected from natural variability, particularly if a reasonably sized geographic region is considered.

In spite of these concerns, the U.S. is presently considering something like the WWA, which is being investigated by a NASEM Panel on Attribution of Extreme Weather and Climate Events and their impacts.

<https://www.nationalacademies.org/our-work/attribution-of-extreme-weather-and-climate-events-and-their-impacts>

Extreme weather events can be extreme in terms of the magnitude of individual events, the frequency of events crossing some threshold, or clustering of extreme events. It needs to be acknowledged that extreme events are by definition rare, and short historical records (even century long records) are insufficient for formulating meaningful statistics about return times and event likelihood.

Case studies from two recent high impact extreme events in the U.S. are provided to illustrate the challenges and ambiguities in attributing the frequency and intensity of extreme weather events to human-caused warming.

6.4.1 Case study – 2021 Western North America heat wave

The 2021 Western North America heat wave was an extreme heat wave that affected much of Western North America in late June 2021. In particular, surface temperature records were set in Portland, OR (115 °F; previous record 107°F) and Seattle, WA (108 °F; previous record 103°F).

The WWA provided the following attribution statements:

<https://www.worldweatherattribution.org/western-north-american-extreme-heat-virtually-impossible-without-human-caused-climate-change/>

<https://www.worldweatherattribution.org/wp-content/uploads/NW-US-extreme-heat-2021-scientific-report-WWA.pdf>

- Based on observations and modeling, the occurrence of this heatwave was virtually impossible without human-caused climate change.
- The event is estimated to be about a 1 in 1000-year event in today's climate.
- The event would have been at least 150 times rarer without human-induced climate change.
- This heatwave was about 2°C hotter than it would have been if it had occurred at the beginning of the industrial revolution (when global mean temperatures were 1.2°C cooler than today).

Mass et al. (2024) summarizes the proximate sequence of compound events leading to the heat wave. There was a record-breaking midtropospheric ridge over the Pacific Northwest, forced by a tropical disturbance in the western Pacific. This produced record-breaking midtropospheric temperatures, strong subsidence in the lower atmosphere, low-level easterly flow that produced downslope warming on regional terrain and the removal of cooler marine air, and an approaching low-level trough that enhanced downslope flow. The event occurred at a time of maximum solar insolation, and drier-than-normal soil moisture. Using a storyline approach, Mass et al. assessed that there is no trend in drought and dry soils in the Pacific Northwest; there is no evidence of global warming producing stronger ridges of high pressure, and no observed trend in heat waves or record temperatures in the region. They concluded that although anthropogenic warming may have contributed as much as 2°F to the magnitude of the event, there is little evidence of further amplification of the event from increasing greenhouse gases.

<https://journals.ametsoc.org/view/journals/wefo/39/2/WAF-D-23-0154.1.xml>

A more sophisticated statistical analysis of a model-based attribution study of this heat wave was conducted by Bercos-Hickey et al. (2022)

<https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2022GL099396> Because this event is a far outlier and far above the bounds of Generalized Extreme Value distributions fitted from historical data, they concluded that estimates of return times, quantitative changes in event magnitude and frequency, and probability of the extreme temperatures such as provided by the WWA are not accurate and are made with low confidence. They found that hindcast attribution methods using an ensemble of regional climate models, combined with Pearl (2009) causal inferences, can provide limited and conditional information about the magnitude of the human influence on this heatwave – they provided a more highly constrained estimate that human activities caused a ~1.4°C–1.8°F increase in the daily maximum temperatures.